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Domestic Electrical Appliances Consumption: The case of Centre of Foundation Studies for Agricultural Science UPM Students

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***Abstract*—The electrical consumption for domestic applications in Peninsular Malaysia is investigated in this paper. The study is performed among the homes of Physics students at Centre of Foundation Studies for Agricultural Science, Universiti Putra Malaysia (UPM). The approximately 500 homes in Peninsular Malaysia are selected in this study, where the electricity in this region is governed by Tenaga Nasional Berhad (TNB). The purpose of this study is to recognize the electrical usage for the various types of household electrical appliances, together with their cost which contribute to the amount of electric bill. As a result, this study will be able to determine which household appliances consumes the most energy and cost. Thus, the paper also includes several practical ways to conserve electricity.**

Keywords—Electrical appliances; Tenaga Nasional Berhad; electricity usage; Peninsular Malaysia

I. INTRODUCTION (*Heading 1*)

In the public domain, electricity provides a number of different services to households, such as water heating, lighting, space cooling and so on. Thus, these electricity-consuming appliances has a considerable influence on total electricity consumption and cost of electric bill. Therefore, the electrical appliances have been categorized according to their pattern of use: continuous, standby, cold and active. Continuous appliances use continuous constant power amount (examplles: clocks and burglar alarms). Standby appliances, in have three basic modes: in use; on standby; or switched off. Mode standby is working when an appliance is not in use but the power is consumed. Even the appliances are switched off, they can be on standby mode and the only way to prevent them drawing power is to disconnect their power supply. The examples of the appliances which always appear on standby mode are televisions and set-top boxes. Cold appliances (fridges and freezers) have the range of power consumption starts from zero until a set power level which is under thermostatic control. However, these appliances are always in continuous use. [1]Active appliances are those which are actively switched on or off by the householders and have no standby mode. Examples of active appliances are kettles and electric showers.

The reports on electric consumption for various countries are reported, based on commercial buildings. A monitoring study of the electricity consumption of a sample of UK domestic buildings is performed [1]. The measured results of electricity consumption and cost in a large acute hospital in subtropical Taipei City of Taiwan [2]. The estimation of energy use in office buildings in Malaysia is analysed by Saidur [3]. Electricity consumption data were collected from a sample of UK public house-restaurants [4]. The case of the energy consumption profile of the Aristotle University of Thessaloniki, in Greece, is presented [5]. The energy consumption of electrical appliances for a household is analysed in order to identify the energy consumption pattern for residential area (Batu Pahat, Johor, Malaysia) [6].

The various of characteristics, which contribute the level of electrical power consumed are also reported, year by year. Craig et al. [7] and Anderson et al. [8] analysed the electricity consumption and household characteristics based on the following factors: 1)

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number of residents, and 2) the number of children. These reports [7, 8] is motivated by the previous studies, stated that household electricity usage strongly depends on these two factors [9, 10]. In addition, the effect of climate, building characteristics, appliance stock, and occupants' behavior on residential electricity consumption are studied [11]. Subsequently, Chen [12] found that gross domestic product (GDP), employment rates, and residential space may lead to an increase in residential electricity consumption. The price of electricity consumption are also taken into account, since there is a relationship between price and consumption [13, 14]. Besides, the impact of internet usage on electricity consumption are investigated, for countries of Commonwealth of Independent States [15], and in developed and developing countries [16-19].

Motivated by the previous study [6], the energy consumption of electrical appliances for a household will be analysed in order to estimate the energy consumption pattern (usage and cost) in Peninsular Malaysia. The approximately 500 homes in Peninsular Malaysia are selected in this study. These homes are owned by the guardians/parents of Physics students at Centre of Foundation Studies for Agricultural Science, Universiti Putra Malaysia (UPM). The recommendation and solution will be proposed at the end of this study to help consumers to reduce the energy consumption.

II. METHODOLOGY

Each students have to calculate the total monthly energy consumption of the electrical appliances such as air-conditioner, fan, lights, washing machine, dry iron, refrigerator, rice cooker and television. These appliances are selected due to the assumption that they are used by the majority of the homes in Peninsular Malaysia. Generally, this paper divides appliances into five sections: 1. comfort, 2. lighting, 3. cooking, 4. recreation, and 5. cleaning. These sections represented by the function of household appliances. Their descriptions are as follow:

1. The examples in the comfort section are room air conditioners, de-humidifiers, air cleaners, and fans. Their functions are to provide comfortable temperature and air quality in the living space. For instance, air-conditioners reduce the room temperature. On the other hand, air ventilation provides a continuous supply of fresh outside air and helps to maintain temperature and humidity at comfortable levels.
2. The appliances for cooking section are as follow: refrigerators, rice cookers, micro ovens and water dispensers. The main reason for having a refrigerator is to keep food cold, due to the fact that low temperatures will make food stay fresh longer. Refrigerator works by slowing down the activity of food bacteria, so that it takes longer for the bacteria to spoil the food. The thermocouple in the rice cookers is used to detect the changes of temperature in the inner pot, and switches off the heating element when the temperature in the inner pot is above boiling point. The heating element switches off when the water in the inner pot is been absorbed or turned to steam.
3. Lighting systems provide adequate lighting for residential sectors, including fluorescent lamps and light emitting diode (LED) lamps. A fluorescent lamp uses electricity to excite mercury vapor in argon or neon gas, resulting in a plasma that produces short-wave ultraviolet light. This light then causes a phosphor to fluoresce, producing visible light. An LED lamp or LED light bulb is an electric light which uses one or more light-emitting diodes (LEDs).
4. Recreational appliances include personal computers (PC), television and audio equipment. Nowadays, more people use computers with internet services. Besides, In terms of technology and trend radio is considered outdated while television is been a sophisticated tool ever. Television provides feasibility to view the video and provides channel to change to the radio function, whereas radio only provides entertainment in sound medium.
5. Cleaning-use products consist washing machines, range hoods, clothes dryers, dish dryers, electric iron, and water heaters. The centripetal force is applied for drying clothes in a washing machine is. This force acts along the radius outwards and hence can be used to throw the water molecules on the clothes radially outwards during the spin cycle of the washing machine. On the other hand, steam iron works faster than a dry iron. It is because the existence of steam will loosen up the fabric creases with moisture and the heat will work immediately to smooths out the fabric.

To calculate the consumption of an electrical appliance in kWh, these factors have to be taken in account: 1) the capacity of your electrical appliance, expressed in watt, 2) the number of hours that the appliance is in use in one day, and 3) the number of days per month when the appliance is in use. The calculation is as follows:

$$\frac{(\text{Number per hours use}) \times (\text{capacity of appliance expressed in watt}) \times (30)}{1000} = \text{Amout of usage in kWh} \quad (1)$$

Electricity in Malaysia is governed by Tenaga Nasional Berhad (TNB), and involve in generation, transmission and distribution of electricity. Therefore, the cost of electrical power (in Ringgit Malaysia, RM)

consumed by each household is subjected to the TNB's electricity tariff [20], as shown in Table 1.

Finally, the total electrical consumption (in kWh and RM) are collected and summarized for 500 homes in Peninsular Malaysia and presented in the forms of bar graphs. Furthermore, this study aims to identify the relationship of households towards the increasing energy usage and bill at home.

TABLE I. TNB'S ELECTRICITY TARIFF FOR DOMESTIC HOUSEHOLDS

Tariff Block (kWh)	Rates (RM)
For the first 200 kWh (1- 200 kWh)	0.218
For the next 100 kWh (201 - 300 kWh)	0.334
For the next 300 kWh (301 - 600 kWh)	0.516

III. RESULTS AND DISCUSSION

The data regarding to the electrical usage (in kWh) and bill amount (in Ringgit Malaysia RM) for 500 residents in Peninsular Malaysia is shown in Figure 1. It can be seen that air conditioner shows the highest usage compared with the others. It is also shown that total energy consumption of air conditioner is between 50000kWh and 60000kWh (costing from RM30000 to RM40000). This is because consumers are heavily relying on air conditioners to cope with the hot weather in Malaysia. Due to the hot weather in Malaysia, it may potentially grow in installation and electricity consumption. On the other hand, the second commonly used electrical appliances in Peninsular Malaysia is refrigerator. This type of household consumes electrical usage from 30000kWh to 40000kWh, and amount of bill is from RM10000 to RM20000. Fan and light consume electrical usage between 10000kWh and 20000kWh (costing up to RM10000). However, rice cooker consumes the lowest electrical usage, and records below RM10000 and 10000kWh. As a conclusion, electrical consumption for the individual household is depend on the time period of usage and the capacity of the household itself. Air-conditioner and refrigerator rank top electricity consumption due to the large capacity and long time usage. Besides, the lowest usage of electrical household in Peninsular Malaysia is rice cooker due to the fixed time of usage (use only at meal time). Based on individual appliances, the findings show that air conditioner and refrigerator may be selected as the top priority for electricity saving due to their high positive relationship with residential electricity consumption.

The electrical usage, together with the cost on the usage purposes such as for comfort, cooking, lighting, recreational and cleaning is depicted in Figure 2. The households for comforting residents reach highest usage which is greater than 70000kWh usage and as low as RM40000. This finding is not surprising, since air-conditioner is under comfort purpose. Besides, cooking purpose ranked second top due to the electrical consumption by refrigerator. The electricity consumption of recreational appliances ranks lowest among the five patterns. As a conclusion, the electricity saving program in Peninsular Malaysia may select the comfort purpose of electrical appliances as the priority for future improvement in both the installation and energy efficiency.

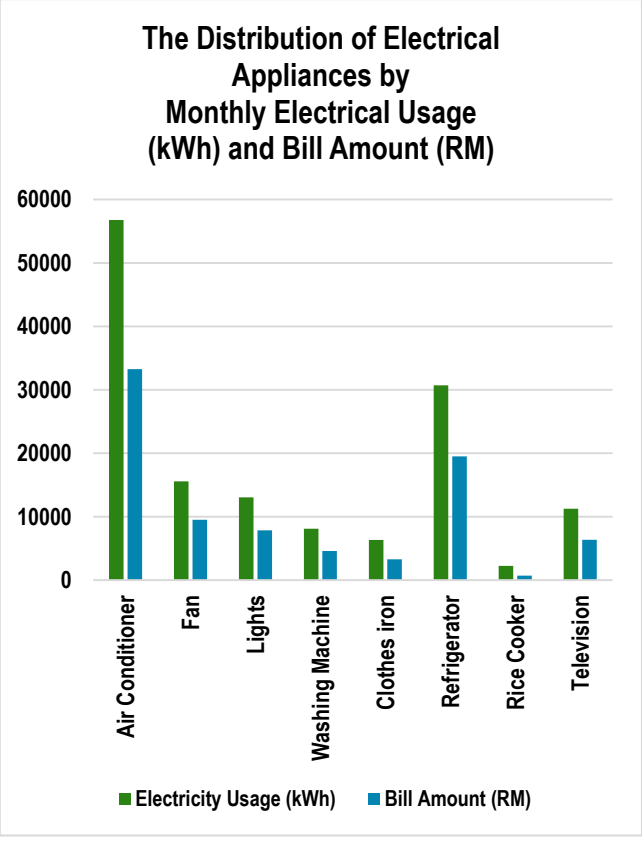

Fig. 1. *The distribution of electrical appliances by monthly electrical usage (kWh) and bill amount (RM)*

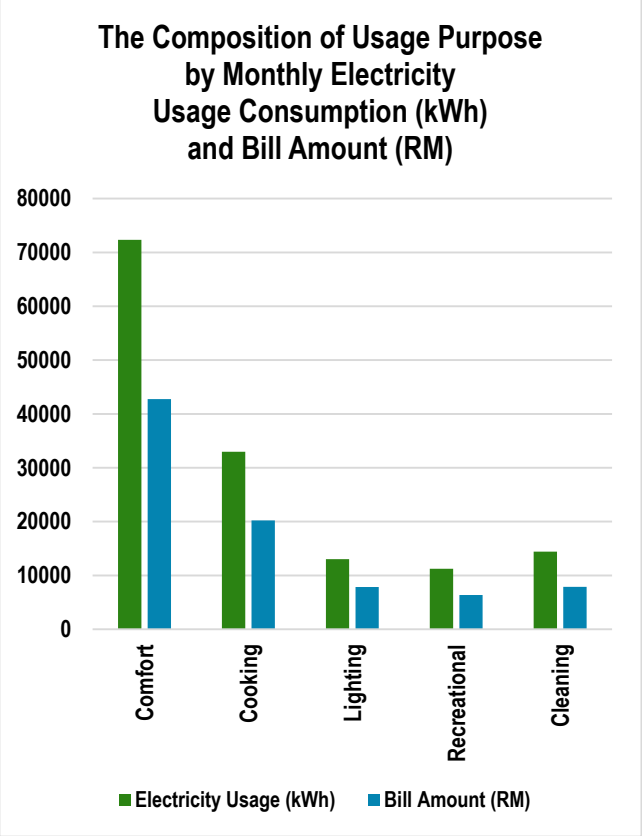

Fig. 2. *The composition of usage purpose by monthly electrical usage consumption (kWh) and bill amount (RM)*

IV. CONCLUSION

The results obtained by the 500 residents in Peninsular Malaysia showed that the individual household significantly affect the electricity consumption and cost. Therefore, the several proven ways to save electricity at home are provided in this section. These ways are listed down, as below:

1. Air conditioner is one of the major contributor to the big amount of electric bill. In addition, it is unavoidable to use the air conditioner in Peninsular Malaysia. One way to save money while using the air conditioner is by selecting Dry mode. By using the Dry mode, electricity usage is saved by as much as 30%. This happens because the fan unit runs slower and the compressor unit runs less frequently when compared to using Cool mode. Another way is to set the temperature to a slightly higher than the usual comfortable temperature. Low temperature will consume more electricity as the compressor runs for a longer time period to bring the temperature down. The regular air conditioner service has to be perform, to have it run most efficiently for energy savings. These maintenance steps can be done by own and do not require a service technician. These steps are as follows: a) Check the condenser, ductwork and remote control, and b) Check and clean filters and evaporator.
2. Refrigerator is also one of the main factor of an increasing electric bill. Fortunately, the energy cost due to refrigerator can be reduced. Properly performing regular refrigerator maintenance will not only help it to last longer, but it will help save energy as well. Maintaining refrigerator includes: check the condition of coils and compressor, regularly defrost the freezer, and make sure there is no air leakage. Another way is keep the refrigerator or freezer set right temperature. The inappropriate low temperature will use up more energy and end up with a much higher bill. Besides, the refrigerator must be located strategically and the coolest spot in the kitchen. It should not be located near windows and cooking appliances. Heat from these sources can cause the refrigerator to expend more energy to keep cool.
3. However, the consumers must have an awareness and alternative ways to save electrical energy. The habits to conserve energy are: a) Pull the plug on appliances when not in use, b) use an appropriate household depends on the conditions (use fan instead of air conditioner at night), c) The electrical appliances which are high energy efficiency based on the energy star rating should be used, to save more energy. On the other hand, the alternative ways to save electric usage are: a) Use lighter paint to maintain room temperature, b) Installing more leafy plants and trees to block heat from getting into home, and c) upgrading to high-performance windows that have special coatings, can filter out up to 70% of the heat while allowing the full amount of visible light to come through.

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