A CONCEPTUAL DESIGN OF AN ALTERNATIVE METHOD FOR CUTTING OFF STANDBY POWER CONSUMPTION FOR OFFICE EQUIPMENT

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I would like to dedicate this project report to my family and my in-laws especially to my beloved wife and daughter. I will always appreciate all they did and their words of guidance will always be remembered.

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ABSTRACT

Ever since the completion of Politeknik Kuching Sarawak (PKS) first major networking project in 2002, its energy consumption has been in the steady rise. Although the increment was understandable, the increasing energy wastage in terms of standby power consumption by ICT equipment and equipment not being switch off was intolerable. With the aim of finding the solution to this issue, the project was divided into three parts. The first part of the project surveyed the level of awareness among the staff during a monthly assembly and found out despite the high level of awareness among the academic staff, some 38% of them admitted they do not switch off their computer and thus jeopardizing the management's desire to put a stop to energy wastage. Secondly, the field measurement of ten types of selected office equipment has been carried out with minimum five samples of measurement taken whenever possible to produce a good average value. The bottom-up estimation method then put the annual standby power consumption of PKS at 64,653.11 *kWh* and cost a staggering *RM* 21,982.06. Finally, unlike the conventional method of using current level detection to detect appliances going into standby mode, the project came out with an alternative standby power cut-off system that utilises light source as a mean of controlling the system and is suitable for the usage in an office environment.

ABSTRAK

Semenjak selesainya pelaksanaan projek rangkaian Politeknik Kuching Sarawak (PKS) yang pertama pada tahun 2002, keadaan penggunaan tenaganya telah memperlihatkan suatu peningkatan yang mantap. Walaupun peningkatan ini dapat di terima dengan baik, pembaziran tenaga dalam bentuk penggunaan *standby power* oleh peralatan ICT dan peralatan yang terlupa dimatikan adalah sesuatu yang tidak dapat di terima. Berbekalkan matlamat untuk mencari penyelesaian kepada isu ini maka projek ini telah dibahagikan kepada tiga bahagian. Bahagian yang pertama telah membuat kajian terhadap tahap kesedaran di kalangan staf semasa perhimpunan bulanan dan mendapati bahawa walaupun staf mempunyai tahap kesedaran yang tinggi tetapi masih terdapat 38% di antaranya yang mengaku tidak mematikan suis komputer dan keadaan ini telah menjejaskan hasrat pihak pengurusan untuk menghentikan pembaziran tenaga elektrik. Seterusnya, pengukuran terhadap sepuluh jenis peralatan yang terpilih telah dilakukan dengan mengambil sekurang-kurangnya lima sampel bacaan untuk menghasilkan nilai purata yang baik. Kaedah anggaran *bottom-up* kemudiannya meletakkan anggaran punggunaan *standby power* tahunan PKS pada 64,653.11 *kWh* dan bernilai *RM* 21,982.06. Akhir sekali, tidak seperti kaedah konventional lain yang menggunakan pengesanan tahap arus pada peralatan yang beralih kepada *standby mode*, projek ini telah menghasilkan satu sistem alternatif untuk memutuskan *standby power* yang menggunakan tenaga cahaya sebagai sumber yang mengawal pengoperasian sistem tersebut dan ianya sesuai digunakan di dalam suasana pejabat.

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CHAPTER 1

INTRODUCTION

1.1 Preamble

Politeknik Kuching Sarawak (PKS) was the fifth polytechnic established in Malaysia in the year 1988. Ever since the completion of its first major networking project in 2002, PKS has witnessed over the years, a steady climb in its total power consumption. The increment was expected and handled well, until the August 10th, 2009, when the management of PKS can no longer tolerate the wastage of energy, then a circular was issued that highlighted the enormous amount that PKS has spent on the electricity bills each month. Two suggestions were outline in the circular:

(i) Switch OFF the lights/air conditioners during recess.

(ii) Switch OFF the computers when not in use/before leaving the office.

From the observation at several departments/units sometimes later, it is found that these suggestions has been ignored. In addition, most of the office equipment, especially the desktop computer, were just being shut down but never switch off. This means, the appliances are simply put on standby mode, and constantly drawing electricity instead of being switching off. As a consequent, the initiative proposed by PKS to cut down on total power consumption and minimizing energy wastage will never achieve its target.

The idea to implement this project thrived on the issue of energy wastage in PKS. Initial investigation shows that some of the staffs are unaware of standby power consumption. Further observation also suggested that staffs who have easy access to the switches have the tendency to switch off their office equipment at the end of the day.

Ideally, to overcome the standby power issue in PKS, the problems of lacking awareness and those hard to reach switches, must be tackle simultaneously. Raising the awareness can be achieved through talks or seminars. While relocation of the switches or a device can be designed and implemented to assist the cutting-off of standby power of office equipment.

1.2 Problem statement

Since PKS has to pay a huge electric bill every month, the management has come to a conclusion that something must be done to reduce it. Realizing that some of the energy used may be wasted is proven to be a good start for a great quest for conserving energy and help save the earth.

Electrical appliances that stayed in the office, for example desktop computers, printers, copiers, paper shredder, televisions, DVD player, Hi-Fi and etc., are known to consumed a certain amount of energy if not properly switch off. Researchers estimated a microcomputer can use up to 6*W* [1-3] of standby power if not being switch off. Consequently, with estimated one thousand computers lying around in PKS, and if all the microcomputer were not switch off, that sum up to a whopping 6000*W* of load.

To see the impact of these standby loads, the calculation of the total annual standby power consumption using formula (3.1) and its carbon footprint is as shown below:

$$P_A(kWh) = \left(6kW \times \frac{14hrs}{Work\ day} \times \frac{261day}{year}\right) + \left(6kW \times \frac{24hrs}{Off\ day} \times \frac{104day}{year}\right)$$

$$= 36,900\frac{kWh}{year}$$

$$CO_2\ e = 36,900 \times 0.0005925$$

$$\approx 22\ \ metric\ tons$$

From the calculation, we can conclude that only a single type of electrical appliance already consumed 36,900 *kWh* of energy annually plus approximately 22 metric tons of Carbon Dioxide being released into the atmosphere.

1.3 Aim

The main aim of this master's project is to come out with a conceptual design of an alternative method of cutting off standby power consumption for office equipment after office hours in order to prevent energy wastage. While doing so, a study on level of awareness among the staffs regarding standby power consumption and estimation of the annual standby power consumption in PKS was also conducted so that this information can be provided to the PKS management for further action if required.

1.4 Objectives

The objectives of this project are:

(i) To study the level of awareness among the staff.

(ii) To determine the standby power consumption.

(iii) To come out with a conceptual design of an alternative standby power cut-off system for office equipment.

1.5 Scope

(i) To study the level of awareness, a survey will be carried out during the PKS's monthly assembly. In the survey, 150 questionnaires will be distributed randomly among the staffs and a target of at least 100 respondents is set.

(ii) To estimate the total power consumption, a power meter will be used to do the field measurement of selected office equipment in two department in PKS, namely the Electrical Engineering Department and Mathematics, Science & Computer Department. For a type of appliances, at least five samples will be measured whenever possible to obtain a good average value for the estimation. Finally, these average values will be multiplied with the number of equipment available in PKS to make the estimation.

(iii) To come out with a system that is capable of cutting-off power to office equipment when the office is dark. The system will utilize sensor to detect lights being switch on (as indicator of when there are people present in the office) and switch off (as indicator as people leaving the office). The system must allow power supply to pass through when light is detected and must be able to cut-off the power supply when it is dark.

1.6 Structure of report

The introduction in chapter 1 is followed by definition of standby power, review on the method of measurement and the software used in the simulation process in chapter 2. Chapter 3 describes the project planning and methods employed to completes the three major parts of the project. These results are presented and analyzed in chapter 4. This report will end with discussion, conclusions and suggestion for project improvement in chapter 5.

CHAPTER 2

LITERATURE REVIEW

2.1 Preamble

In this chapter, the definition of standby power is being described first, and followed by the review of the standby power estimation method and the standby power cut-off techniques before proceed to the software being used to develop this project.

2.2 Introduction to standby power

The innovation of technology has never stop to impress people with its forever more intelligent functions that enable people to live more comfortably and conveniently. Eventually, standby power has becomes a necessity for almost every piece of electrical appliances produced.

Since the 90s, peoples have started to realise these standby power, although consider relatively small for a single piece of appliance, but gradually add up to a whooping 1.39 *TWh* of annual consumption and with 811t CO_2 emission just for a small country like Taiwan [4].

Prior to 1993, the power losses due to standby mode were considered very small and often ignored. Eje Sanberg became the pioneer when he collected data from TVs, VCRs and audio equipment in the off mode in Swedish electronic stores and called the phenomenon “leaking electricity”. Sanberg’s work was later cited by Alan Meier from Lawrence Berkeley National Laboratory and published in the Home Energy Magazine in 1993. Rainer et al. [5] were the first to do a comprehensive study and came out with estimate average losses per home and national losses in the U.S. in 1996.

Standby power consumption we also known as *vampire power*, *vampire draw*, *phantom load*, or *leaking electricity* [6]. Standby power actually refers to constant consumption of electrical power by electrical appliances when they are put on standby mode. A common used and more precise definition for standby power would be the energy consumption by electrical appliances when they are switch off or are not performing its principal function. The mathematical formula to calculate standby power consumption is as follows:

$$E_S = P_S \times t_S \tag{2.1}$$

E_S: Standby power consumed in watt-hour per day or year

P_S: Effective output power on standby mode, watts

t_S: Period of standby mode, hours

2.2.1 Definition

Although there are so many definition available for standby power but it is still inadequate in technical purposes. The most detailed description of standby power according to Lu et al. [4] is from the Australian National Appliance & Equipment Energy Efficiency Committee (NAEEEC). The definitions are:

(i) *OFF* mode:

When the electrical product is connected to power but not is not executing any function, and if the device has a remote control function, that remote control cannot activate the device directly from this mode.

(ii) *Passive standby* mode:

When the electrical product is not in execution of its primary function, but the standby mode is enabled (usually for use by the remote control device), or in execution of other functions (such as displays or clocks). When the electrical product is not plugged in, the equipment is able to make use of battery power under this mode.

(iii) *Active standby* mode:

Active standby mode refers to an electrical product in the enable mode, but not in execution of its main functions (for example, a VCR in enable mode, but not showing a video or recording).

(iv) *Delay start* mode:

In this mode, the user is able to schedule the electrical product, through a computer program, to perform a certain function later, which can be delayed for up to 24 h.

2.2.2 Advantages and disadvantages

As technology advances, the standby power usage becomes inevitable to make life more comfortable and convenient. The advantages of standby power are listed as follows:

(i) It cut short the delay time in switching on a device. For example, in office equipment such as the CRT monitors this requires a small amount of current to heat up before they are switch on.

(ii) It is used to keep providing power to remote control receiver so that when an infrared or radio frequency signals is received it will respond instantaneously.

(iii) It is used to power a display function such as clock and will enable less power being used.

(iv) It can be used to keep a device's battery fully charged and ready to be used like the mobile telephone.

The standby power consumption becomes the setback of the technology advancement as energy is wasted without the device performing its primary function. The disadvantages of standby power are listed as follows:

(i) It consumes a small amount of energy per device but is estimated to be of the order of 10% of the energy used by a typical household.

(ii) It causes more carbon dioxide to be released into the atmosphere and promoting global warming because more energy has to be produced resulting in more oil, coal and gas combustion.

(iii) It will incur more running costs as more power generation, transmission and distribution facilities to be set up.

(iv) It will create a risk from fire as there are reports of television catching fire on standby mode [6].

2.2.3 Magnitude

According to the study by the US Department of Energy, and illustrated here by Lloyd [7], a device can have an annual standby power consumption between 12.3*kWh* for a rechargeable toothbrush to a whopping 1452.4*kWh* for Plasma TV as shown in figure 2.1 below. The study also estimated the total standby power consumption in 2005 for US stood at 3 billion US dollars.

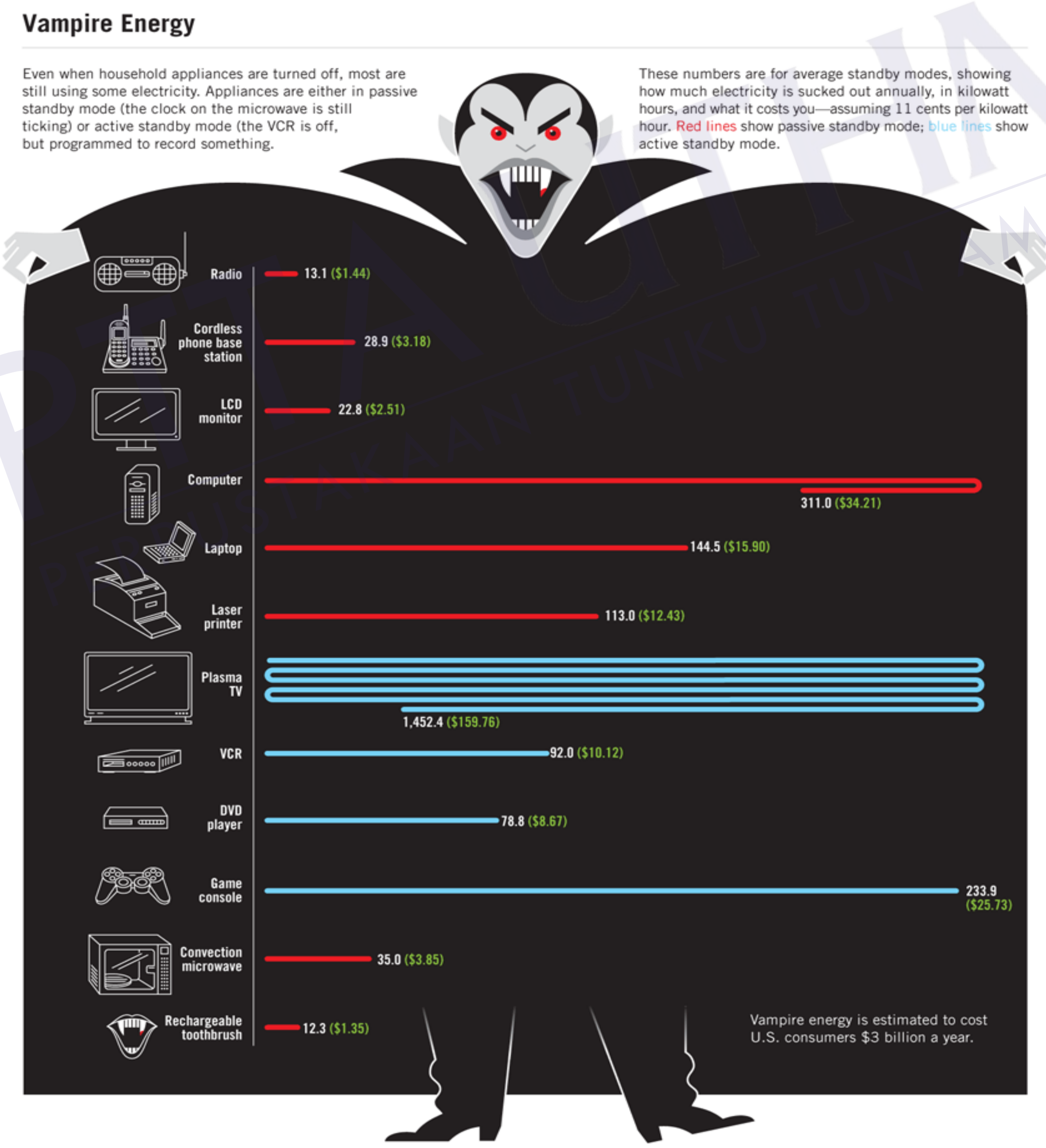

Figure 2.1 The visual display of vampire information

To get a clearer picture of the magnitude of standby power consumption around the world, Table 2.1 has listed figure found in research since 1995 for a total of eleven countries. From the table shown, the average and annual standby power consumption per household in these countries stood approximately at 50*W* and 400*kWh*. Apart from that, the fraction of total residential electricity used is about 10% on average and total carbon dioxide gas released is 0.2295 metric ton annually.

If this estimation were to be set as a standard for other country to estimate their annual standby power consumption, then the country like Malaysia would have the estimation as follows:

Malaysian annual standby power consumption,

$= 401.13\ kWh \times 6445000\ household^{*} \approx 2.6\ TWh$

Malaysian annual CO_2 emission in metric ton

$= 0.2295\ t\ CO2\ e \times 6445000\ household^{*} \approx 1.5\ Mt\ CO2\ e$

* Based on number of household in 2010 as retrieved from the website: http://www.statistics.gov.my/portal/download_Population/files/BPD/population_quarters_2010.pdf

2.2.4 Policy

The International Energy Agency (IEA) launched the one watt initiative in 1999, in the hope of getting international level of cooperation towards solving the issue. The initiative outlined that by 2010 all new electrical appliances sold in the world would only use one watt in standby mode. The outcome of this initiative includes reducing the CO_2 emissions by 50 million tons by 2010 in the Organization for Economic Co-operation and Development (OECD) countries alone.

To accommodate the one watt initiative by IEA, the European Commission (EC) regulation number 1275/2008 came into force in January 6, 2010. It is mandatory under the regulation that all electrical and electronic household and office equipment shall not have standby power that exceed 1*W* while *standby plus* power (i.e. providing information or status display in addition to possible reactivation function) shall not exceed 2*W*. The regulation also stated all equipment must have the off mode and/or standby mode provided, plus these numbers of

Table 2.1 The magnitude of standby power consumption of 11 countries

No.	Country	Average Residential Standby Power (*Watt*)	Annual Electricity Use (*kWh/yr*)	Fraction of Total Residential Electricity Use (%)	CO_2 emission in metric ton ($t\ CO_2 e$)
1	Netherlands	37	330	10	0.1955
2	USA	50	400	5	0.2370
3	German	44	389	10	0.2305
4	Japan	60	530	12	0.3140
5	New Zealand	100	880	11	0.5214
6	France	38	235	7	0.1392
7	Australia	60	527	13	0.3122
8	Canada	49	427	N/A	0.2530
9	China	29	100	10	0.0593
10	Belgium	40	274	8	0.1623
11	Taiwan	Off mode, Passive standby, Active standby, and Delay Start mode	Class A: 104 Class B: 212 Class C: 186 Class D: 223 Ave=181.25	N/A	0.1074
Average		49.27	401.13	10.40	0.2295

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