Intelligent Lighting System: An Education Kit to Increase the Awareness of Energy-Saving for Primary School Children.

By

Lee Siew Kwan

Dissertation submitted in partial fulfilment of
the requirements for the
Bachelor of Technology (Hons)
(Business Information System)

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Universiti Teknologi PETRONAS,
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CERTIFICATION OF APPROVAL

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Approved by,

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September 2012

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

LEE SIEW KWAN

ABSTRACT

High energy consumption per capita reported in our country has shown a significant issue pertaining to the overconsumption of electricity. This issue has become a problem when the negative effects of climate change are felt by citizens. Thus, public must be taught to be energy-saving conscious, especially from their young age. However, there is a lack of such education material to teach the young generations. Thus, this report presents an education kit, which consists of an education website, a prototype and a case study, which aims to increase the awareness of energy-saving in the young minds of the primary school students. The website acts as an interactive tool for students to learn about energy-saving and how the prototype works. The prototype consists of an intelligent lighting device that uses a combination of sensors, or dual-technology to reduce unnecessary electricity consumption of lighting in a target building. The case study focuses on academic building Academic Building 2 in Univerisiti Teknologi PETRONAS (UTP), where the lighting consumption pattern is studied, and how the intelligent lighting system can help to reduce the unnecessary electricity wastage within lecture room in the campus. The methodology used is Rapid Application Development (RAD) cycle and prototyping, where the website and the prototype are developed and tested on a regular basis. Findings have shown that UTP is consuming a very high amount of electricity, and the intelligent lighting system is estimated to reduce up to 36.58% of electricity spent on lighting in Academic Building 2. In short, the whole package is interactive and educative to the primary school students to learn about energy-saving in an unprecedented way.

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ABBREVIATIONS AND NOMENCLATURES

IT	Information Technology
BAS	Building automation systems
EMS	Energy management systems
UTP	Universiti Teknologi PETRONAS
USM	Universiti Sains Malaysia
WSN	Wireless Sensor Network
BEST	Berkeley Expert Systems Technology
RAD	Rapid Application Development
PIR	Passive Infrared
BEI	Building Energy Index
GBI	Green Building Index
HVAC	Heating, ventilation and air conditioning
PIC	Peripheral Interface Controller
ROHS	Restriction of Hazardous Substances

CHAPTER 1
INTRODUCTION

1.1 Background of Study

The electricity consumption is getting higher and higher in the country. This can be proven by the increase of electricity consumption per capita from 2,468.48 kWh in year 2001 to 3,265.04 kWh in year 2011. This leap is believed to be caused by several factors. The main factors are the lack of awareness of the importance of energy-saving, and over dependent on cooling and lighting system especially in household and commercial buildings. This scenario is obvious in UTP too, where students and staffs do not switch off light once they leave the classrooms, thus energy is wasted. Besides, it pollutes the environment, since non-renewable resources are used to generate electricity.

In order to resolve this issue, education is necessary, especially to begin earlier from younger age, such as during primary school. However, there is lack of such devices or materials to be used to teach the students effectively, which is also another factor of causing the problem to persist. Thus, a new package of tools should be developed as the materials for students to learn and experience. An education kit with a website as reading material, prototype as hands-on device and a case study for explanation on real scenario is the solution to the problem. The education kit is believed to be able to promote green IT initiative to the younger generations, especially primary school students with a more entertaining and appealing way.

The **green IT** or green technology refers to the initiatives to use and design information technology and communication to reduce the negative impacts caused by human activities towards the environment. The definition of green IT is broad. To define it, it depends on the party who is addressing the issue. Generally, it has three main categories which includes sustainable IT in manufacturing which refers to the methods of producing environmental friendly products. Next category looks into the management and their ways of handling its IT assets, such as purchasing energy-efficient laptops. Lastly, it refers to sustainable IT disposal where the IT assets are safely disposed once cannot be used.

D. Tebbutt et al (2009) states that IT can help organisation to go green and minimise its environmental impact. According to the same authors, IT can be use to control energy, particularly electricity consumption, by preventing energy wastage. For instance, using movement sensors, thermostats and computer switches to switch devices between on and off in order to manipulate them.

Building automation systems (BAS), such as lighting and temperature controls, are common in large facilities (D. Du Bois, 2007). **Energy management system** (EMS) goes deeper, where it centralizes the control of lighting, heating, ventilating, and air conditioning with the objective of reducing energy consumption. Almost every big campus, such as hospital and universities has implemented these systems. According to Malaysian Standard (2007), lighting system is normally the second largest energy consumer in a building and thus should be considered to be included in the EMS. There is a centralized control of lighting system in the academic building in UTP, however, it is not being utilized, which is why causing the electricity consumption to be high.

The **prototype** highlighted in this report is an environmental friendly intelligent lighting system. It is an automatic lighting device, which uses motion sensor or occupancy sensor and a light intensity sensor which aims to prevent energy wastage in a targeted area. It is a green IT because it switches off unnecessary lights when a classroom is not occupied, thus saving energy. It will be used to estimate the amount of energy saved in Academic Building 2 in the case study later.

The combinations of **motion sensor** and a **light intensity sensor** in lighting system are not rare in the market. However, it usually offers separately in most lighting products in the market. The purpose of combining the two sensors is to detect human presence and to measure the brightness in the classrooms. Once the room is occupied, and daylight is insufficient, the lighting system will be switch on, or else it will not. The concept used is **daylight harvesting**, also called daylighting. It is a sustainable architecture term which means the utilization of natural light through windows and skylights, to reduce the usage of artificial light in order to save energy.

This **case study** is done based on the context in academic blocks in UTP only. It may not applicable for other buildings due to different scenarios. It studies the electricity consumption pattern of lighting in the campus, and to estimate how much energy can be reduced by using the lighting system as proposed in the prototype. The **website** acts as the source of reading material for the target user of the education kit. The main purpose of the website is to store information, such as videos on how the prototype works.

1.2 Problem Statement

High demand of electricity in the country generates a huge quantity of greenhouse gases to the environment. These gases increase the temperature in the atmosphere and causes global warming which in turns lead to the occurrence of disasters such as flash floods. This issue is mainly due to the lack of awareness of the public towards the importance of energy saving, especially on lighting consumption. In order to resolve this issue, education is important, particularly to begin earlier from the younger generations. However, there is a lack of a complete set of tools to help in solving this problem.

In UTP, there is a centralized control system at the academic blocks in the campus, where all the lights and air conditionals are centralised and manipulated by main control. However, the lights are being turn on and off irregularly without concerning the occupancy and the daylight intensity inside the lecture rooms, especially classrooms which are accessible by students. This situation caused so much waste of electricity, and is similar to the general scenario in the country, whereby people are unaware of the importance of energy-saving.

The problem of wasting energy can be observed in Academic Building 2, as shown in the figures below.

Figure 1.2.1 : Unoccupied classroom with lights switching on.

Figure 1.2.2 : Partially occupied classroom with sufficient day light from glass window, with lights switching on.

By creating the automated lighting device, it can help to solve the problem of unnecessary electricity consumption by only switching the lights on when a lecture room is occupied, and the day light is insufficient. It can help to reduce energy wastage, thus benefit the environment.

The significance of having an education kit is to solve the issue of overconsumption of electricity from the root cause, which is the user themselves. The target users of the education kit are primary school children from age 7 to 12. It is easier to educate young kids since their minds and behaviour are more readily to be shaped. It will be more effective to use a prototype to provide hands-on experience for the children to learn, and the videos in the websites to listen to, rather than plain text book which is not appealing to the users. This education kit can help teachers to transfer scientific knowledge to the primary school students in an entertaining and more attractive way, at the same time, promote the use of green technology initiative to reduce energy consumption to the younger generations.

1.3 Objective

To develop an education kit that consists of an education website, a lighting device and a case study, to increase the awareness of primary school children about the importance of energy-saving.

Sub-objectives:

(1) To design and develop a lighting system using a PIR sensor module and a light intensity sensor.

(2) To build an educational website to explain about the lighting system and the importance of energy-saving to the primary school children.

Scope of Study

Location of case study is the Academic Building 2 within the campus, Universiti Teknologi PETRONAS (UTP), where specifically focus on classrooms or lecture rooms in the block.

The case study focuses on how to use technology to minimize electricity wastage of current lighting system in the campus. It also studies about the pattern of consumption of lighting in the academic building.

This section will describe briefly about the areas studied.

Education kit is a package which consists of education materials, such as pens, pencils, textbooks, disk, tools or anything that facilitates and enhances training, teaching or learning purposes. Examples of education kit in the market include PicoScope Education Kit for students and teachers to perform a variety of experiments. Other example will be the Australians at War education kit that contains televisions series about the effects of war on the lives on of Australians for primary and secondary schools.

Intelligent Lighting System refers to a system where multiple lighting fixtures are connected to a network and user needs are met by cooperation of the various lighting fixtures (M. Miki, et al, 2004). The basic feature of the system consists of autonomous distributed control, the ability to achieve a switching pattern independent on wiring and the capability of achieving autonomous lighting control.

1.4 Relevancy and Feasibility of the Project

Nowadays, primary school students are started to expose to electronics in class. The project is relevant because there is a lack of such education kit in the market for primary school children to learn about energy-saving. Besides, trend of using automatic lighting system is low in our country, compare with developed counties such as France where lighting system using sensors is common. In our country, other universities have tried to contribute to the environment by all sorts of events. For example, in 2008, Universiti Sains Malaysia (USM) began its first green project by cooperating with Tupperware Brands Malaysia, to start a programme where use of Styrofoam is banned and use of personal Tupperware is encouraged. Other university, University of Nottingham Malaysia also had its first green week on year 2011, which aimed to reduce consumption of polystyrene food containers in the campus. It shows that more has to be done in order to truly help the environment. In order to achieve this, technology much be used. Thus, an education kit that aims to increase the awareness of energy-saving in the primary school children is able to help.

The project is feasible to be carried out, economically and technically. Simple sensors can build up the lighting system and it can be achieved within budget, RM500. Besides, building a website is convenient and bare no cost. The website in this education kit is built up by using online free hosting, wix html editor. Lecturer and expertises from other departments have also been approached as the source of references, making the project more feasible to be completed. The time given to complete the whole FYP 1 and FYP 2 is around 8 months, which is sufficient for the prototype, case study and the website to be completed.

CHAPTER 2
LITERATURE REVIEW AND/OR THEORY

2.1 Examples of Education Kit

A few examples of educations kit are studied. The first example of education kit is a child nutrition health education kit that acts as a source of information designed to help professionals, school nutritionists and teachers to ensure the health of the children they are taking care of (National Dairy Council).

Another example is “The Fantastical Imaginings of Tim Burton”, an education kit for readers to study about Tim Burton and his productions, such as a film or a piece of drawing. It contains questions about related topics and requires the reader to think and discuss about it (V.Stranieri).

“Emergency Triage” is also another education kit for Emergency Departments members in the hospitals to assess urgency of patients in order to treat them according to priority when presented to the emergency departments (Australian Government, Department of Health and Ageing).

“Tutankhamun and the Golden Age of The Pharaohs” is an education kit made for teachers and students who are visiting the exhibition in the Melbourne Museum. It contains questions, web links, activities and task for students to engage in, before or after visiting the exhibition (National Geographic).

Thus, generally, education kits represent materials to be used to enhance the knowledge of a target group of people typically students about a topic. These materials usually include user manuals, videos, activities, task and exercises for students to engage in.

2.2 Education Kits for Green Technology

Several online companies which are selling education kits regarding green technology are reviewed and discussed.

"Horizon Fuel Cell Technologies" is a company based on Singapore that develops and commercializes a series of renewable energy science experiment sets. These education kits are battery free and focus on the use of renewable energy, such as sunlight, wind and hydro. Examples of education kits include renewable energy education lab, wind pitch education kit and hydro car education kit. These education kits comprised of comprehensive textbooks, experiment manuals, teacher notes, classroom guides, videos and other files. These miniature education sets are designed for teaching and learning about renewable energy science in classroom environment as well as interactive activity sets for family.

The similarity of these products with the education kit in this project is that both aim to promote green technology, especially to the children who are the main user of these products. The difference is that it focuses on renewable energy or clean energy, and does not produce any lighting system or similar education kits that are functioned by using sensors.

"Sundance Solar" is another company that develops similar education kits for children at the age of 7 and above. It is based in United States. It products range from solar energy for kids, wind and hydro power educational kits, environmental and weather learning kits, fuel cell educational kits and sun bender do-it-yourself solar kits. Similar with the previous company, it focuses on developing renewable energy educational kits and toys. Further, the educational kits developed by this company are also focus on educating children to be aware of the use of renewable energy in order to preserve the environment. However, same like the previous company, this company does not produce any education kit about energy-efficient lighting, or anything using PIR motion sensor or light intensity sensor, which makes none of the product similar with the education kit in this project.

Another company “Discover This” has developed a product called the “Sustainable Earth lab”. This science kit or education kit allows children to learn about the environmental problems such as acid rain and how the use of technology can overcome these issues. The purpose of the product not only focuses on renewable energy, but also natural resources usage, climate change prevention, waste and water management and energy conservation. This kit is able to show immediate results while giving hands-on experiments to the users. This kit covers a broader field compare with the education kit in this report, since it is not only focus on energy conservation but also other areas.

2.3 Importance of Hands-on Activities in Quality Education

3 Papers regarding the importance of hands-on activities in quality education are studied and reviewed in the following paragraphs.

The advancement of imaging technology in the neuroscience field has allowed scientists to access to critical information about the human brain. P.Schiller (2010) has revealed some of the important findings about the early development of human brain. One of the findings include that the sense of touch helps children understand abstract ideas in concretely. Besides, it is able to improve the ability of making distinctions, recognizing relationships, organizing systems and taking different perspectives. It also discovered that frequent movement during children’s learning process increase quantity of key proteins that build up the brain’s structure for learning and memorizing. This means that hands-on learning is effective in terms of it helps children to understand and remember a concept better compare with ordinary classroom teaching.

M.L. Crawford (2001) mentioned that, students whose teachers conduct hands-on learning can do better than their peers by 70% and 40% grade level in math and science respectively. This paper also stated that students have a chance to apply concepts they learnt when they are engaging in hands-on activities. Besides, hands-on activities that carried out in group are able to improve cooperating skills. Apart from that, it encourages students to think and to reason. Experiencing or by doing hands-on activities is one of the strategies that researchers found effective in teaching mathematics and science. The intelligent lighting system which includes a prototype lighting device is believed to provide meaningful hands-on experience for children to learn about how sensor works, and allow them to think how these sensors can help to save electricity in a lighting system.

S.E. Cooperstein et al (2004) have mentioned that, active learning or constructivist learning starts from experience to knowledge, not the other way. Active learning is effective in a way that it begins with hands-on experiences, where these experiences lead to relationships with concepts and finally students comprehend them and put them into knowledge. Science laboratories and computer laboratories are the best place for students to learn from experience. It is believed that the education kit can do the same. The prototype can help children to convert their experience into knowledge, also to better understand the concept in the website on how the prototype works.

2.4 Field Study on Electricity Consumption

The following article presents the analysis of electricity consumption in UTP from January 2007 to January 2009. It is one of the main references used in the case study.

M.F. Khamidi et al has presented an article entitled “University Teknologi PETRONAS Energy Retrofitting: Turning Challenges into Opportunities.”. The objective of the article is to find out the reason of high electricity consumption in UTP buildings. The studies have highlights that the amount of energy spent by UTP is a lot higher than the average building in the country. It is caused by few reasons, which includes the high cooling demand due to inefficient devices and fixtures, and the irresponsible human behaviour. The studies focused on two academic blocks in the campus, namely block 13 and 14. The study shows that around 20 to 30 percent of total electricity consumption is spent on lighting. It has found that total electricity consumption in year 2008 is 5,576,090 kWh, thus equivalent to a total of RM 334,565 to RM 501,848 spent on lighting on the same year.

This paper has suggested few solutions to cope with the overuse of electricity in the campus. One of the ideas includes utilising energy efficient equipments. It has suggested the use of Energy Efficient (EE) lighting products, such as Compact Fluorescent Lights (CFL) and Light Emitting Diode (LED) which is very common. The authors have also agreed with the idea of retrofitting the current lighting system in order to be more energy-efficient. This has become a motivation to develop a lighting system with improved energy-efficiency, which is a device that has similar function with the prototype.

The next article entitled “Energy Saving Lighting Control Systems for Open-plan Offices : A Field Study.” , written by A.D. Galasiu et al. The purpose of the study is to reduce electricity consumption inside an office area. The lighting is fixed in the middle of cubicle workstations to maximize detection. It uses three methods altogether in the new system, namely occupancy sensors, light sensors and individual dimming control through computer. It replaces the conventional fluorescent lamps into electronic ballast. A total of 86 workstations are examined for a year to record the electricity consumed.

The occupancy sensors save most of the energy, followed by light sensors and individual dimming. It proves that machine can work better to reduce electricity consumption rather than depending on individual. This lighting system is controlled by a central computer in the network. During the study, all lamps are controlled by the network during working hours, from 7.30am to 5pm. The lamp consists of 3 individual 32 W lamps. The light in the middle lamp is facing upward, to brighten the open-plan space. In the system, two lamps on the side are facing downward. It is controlled by the occupancy sensors, light sensors and individual desktop. Software is embedded inside the individual computer to control switching and dimming of the light.

Results show that lighting system records a substantial reduce in energy consumed compared to the conventional lighting system before modification. The amount of electricity is reduced by 42% to 47% by using the three control methods, compare with using the system at full power during work-hours. This is equivalent to an overall reduction of 67% to 69% of electricity compare to the conventional system. The study has also shows that most individual prefer to work below the recommended brightness, which is 300 Lux, shows that lighting system is unnecessary to be open at full power. However, the paper did mention that the initial cost of introducing the system is high. This could be the reason this system is not popular even though the paper is dated back on year 2007. It is still very uncommon in today's technology.

2.5 Smart-Home, Using Sensors to Control Devices at Home

The idea of smart-home is to control devices automatically in order to provide maximum comfort and convenience to the users at home, using a variety of sensors.

Robinson P, et al (2008) describes about a Smart Home system that combines security identification using RFID and customized lighting control for individual. It uses sensors to control lighting automatically. It is different from the proposed system represented by the prototype where it combines the ability to identify individuals and customize lighting preferences accordingly.

The authors wrote about the Smart Home system that combines electronic access control with user identification and a lighting automation scheme. It uses RFID as the main input medium to transmit data within the system. The system controls the entry into a room by using ID-based identification method to verify users. The system links the RFID authentication mechanism to communicate with a microcontroller that will release an electric door strike if authentication is successful. Once it is successful, the system will turn on a set of lights by a pre-determined path of the user. It is customized based on individual.

The purpose of Smart Home system is primarily designed for office buildings where it focuses on security access and energy efficiency, which is similar to one of the main functionalities of the prototype in the Intelligent Lighting System Education Kit. The RFID will track the individuals entering and exiting the premises. Using RFID, it creates an identification-based lighting scheme including photovoltaic switches and motion sensors which as well can achieve energy efficiency because it allows unnecessary lights to be turned off automatically. The expected outcome of the project is a prototype and a room unit.

The system also include a mechanism to manipulate the amount of presence natural light in the room. For example, when an individual enters a dark room, the light from outside will trigger the system to switch on itself eliminating the need to manually switch it on. In this case, it is using a light sensitive sensor such as the photodiode used in the prototype.

The following article reviewed entitled “MavHome: An Agent-Based Smart Home”, written by D.J. Cook et al. This paper describes a project namely MavHome that stands for “Managing an Intelligent Versatile Home”. The purpose of MavHome smart home is to create a home that act as an intelligent agent, using technology that are able to perceive the environment using sensors and act upon changes through control device. Another goal of the project is to maximize comfort level, increase productivity and minimize operational cost.

The MavHome architecture requires the combinations of technologies from database, robotics, machine learning, mobile computing, and multimedia computing. Under this concept, nearly all electronic appliances are able to be controlled by the network, thus minimize the need of user control. For instance, the refrigerator show there is a low on apple, MavHome will place a grocery order, when the home owner arrives, the grocery has arrived at home. The Intelligent Lighting System uses sensors to control the lighting system, it is not as advanced as MavHome, but both aim to reduce complexity, promote comforts and improve the environment.

MavHome uses three special algorithms to run the system. Firstly is SHIP algorithm that are able to learn the habit of the inhabitant, when the inhabitant issue a command to a device, the device will look for the similar history that match and execute the action. The second algorithm used is call Active LeZi algorithm. It uses information theory principles to process historical action sequences. Third algorithm identifies high-level tasks in action sequences to help direct the creation of a Markov Model for action prediction. Markov Model is a way to represent a changing of states, from one states to another, it is a term taken from the medical field. It can be a collection of action sequences that be used to predict the coming action. The limitation of the MavHome is that, it can only be used by one inhabitant. Besides, it does not explicitly mention how cost can be reduced in such an advanced system.

2.6 Human Behaviour as a Challenge in Energy-Saving

The next article entitled “The Dark Side of Occupants’ Behaviour on Building Energy Use”, written by O.T. Masoso et al (2010). The purpose of the study is to find out the occupants’ behaviour towards the used of energy in a building. The results show a shocking fact that energy consumed during non-working hours is higher than energy consumed during working hours. This study was carried out in 6 randomly selected commercial buildings in Botswana and South Africa.

The study records the electricity consumption that can be break down into few categories. Heating, ventilation and air conditioning (HVAC), plug load such as office equipment and lighting. The working hours start from 7.30am to 4.30pm, while public holiday and weekend are considered non-working hours.

The study shows that many reasons cause the wastage of electricity, such as equipments are left to be switching on after working hours, air condition are left overnight, laboratory equipment are left running when not in use. This problem can be solved by fixing sensors and provide educations to the occupants. Energy is also wasted when the whole building is controlled by a single zone centralized air conditioning system. The giant centralised air conditioning system is operating at all days, while practically, not all the areas in the same zone require the air conditionals to be switch on at the same time. This problem can be tackled by proper zoning to separate the areas in the office accordingly.

The article concludes that, to dates, plenty of advanced technologies are created to improve energy efficiency, but the main concern lies in the occupants' behaviours. The advancement of technology can be useless if the users misuse the systems or refuse to participate. Technology is only a tool to help, thus it should be solved by having early education to change the mindset of human behaviour, which is where the education kit can be useful.

2.7 Daylight Harvesting and Occupancy Sensors to Improve Lighting Efficiency

The following is a chapter retrieved from a guidebook written by staffs working in the Lighting Laboratory in Aalto University in Finland. It stresses on introducing several types of lighting systems to the readers.

The literature highlighted that, due to increasing environmental issues, lighting control system in buildings play an important part in energy saving. Often, compare to personnel cost, cost of lighting is consider low, thus its potential of energy saving is usually neglected. As far as concerned, this issue has been neglected in UTP too. Energy saving can be achieved by using smart lighting control strategies. Most of these controls are replaced by automated systems. Many concepts and ways have been studied and proved to be useful, for instance, occupancy sensors, daylight harvesting, time-based controls and dimmer. Furthermore, technology such as smart windows and automatic blinds are also very useful.

According to the book, there are 3 levels of lighting control integration. The prototype of this education kit falls under the second level whereby it takes into consideration artificial lighting and the control by outside information such as daylight harvesting, occupancy and others. Results show that potential amount of saving can range from 10 percent to 60 percent. Nevertheless, it is important to ensure the installation is flawless and maintenances are done regularly to ensure the system to be well-functioning. It has stressed that if possible, after installation, the system should be tested under real condition to ensure its usability. For the prototype developed in this project, it is impossible to be implemented in the whole campus, thus only a prototype is built and tested instead.

The next article entitled "An Intelligent Lighting Control System Based on Ergonomic Research", written by Y.Lin et al. This paper is similar with the paper by V.Singhvi et al where user comfort is taken into consideration. This paper proposed an intelligent lighting control system with adjustable luminance similar with M. Miki, et al (2004). The purpose of the system proposed is to meet the need of illumination adjustable and transformable colour of the lighting system, at the same time, meeting user comfort. The system includes functionality based on ergonomic strategy to meet human comfortableness. These features include adjustable uniformity, correlated colour temperature and duration and transition of different modes, based on ergonomic research.

V.Singhvi et al wrote a similar research paper entitled "Intelligent Light Control using Sensor Networks". This paper presents a system that optimizes the tradeoffs between two objectives, meeting user comfort and reduction of energy usage. The approach use is based on a principled, decision theoretic formulation of the control task. It uses mobile wireless sensor networks to optimize trade off between the two objectives. The study also uses external light sources for additional energy saving, or daylight harvesting. Besides, it also demonstrates that active sensing approach can maximize mobile sensor network's lifetime. In this study, algorithm is necessary for solving underlying complex optimization problems. The results indicate a significant improvement in user utility and reduced energy expenditure.

M. Miki, et al (2004) has proposed an intelligent lighting system that provides the necessary illuminance to a desired location. The results show that various illuminance sensors converged to the preset target illuminance.

Technology has been developed for individuals to control the illuminance of various lights by connecting the lights to a network and systems with a high-level human-interface. However, there are some limitations. For instance, it is impossible to replace the illuminance when a lighting device fails to function, when a lighting sensors are added or when new divisions are changed. The purpose of this research is to solve similar problems at the same time to propose a new intelligent lighting system which save energy and controls illuminance at desire areas. It is different from other papers that it focuses on controlling the illuminance or the level of brightness of the lighting system.

The hardware built consists of controllable fluorescent lights, sensors, and controllers for each light. The algorithm is a newly developed autonomous distributed optimization algorithm, which based on the stochastic hill climbing method. The experiments go through validation process and the results show almost half of the electricity is being reduced. Besides, problems mentioned earlier have also been solved by the system. The results show that the system is very effective and worth to be further developed compare with the studies from other papers.

The next article reviewed is written by R. Yozell-Epstein (2003). The article mentions about electricity utilized by lighting of unoccupied areas depicts a problem of inefficiency commercial lighting usage. It is a problem because gases produced by electrical generation are detrimental to the environment. All these have caused the author to initiate the idea to pursue research in smart sensor-based commercial lighting system.

The motivation of the project concerns about whether interaction between human and environment can be improved upon the usage of smart lighting system. Besides, it also aimed to study if energy saving can be achieved by using wireless network for lighting control. This motive is similar with the paper written by A.A.Nippun Kumaar, et al (2010) whereby wireless sensors are used. This research paper mainly focus on whether the system can be implemented in the Berkeley Expert Systems Technology (BEST) Laboratory at the University of California, Berkeley.

The authors benchmarked the current switching and occupancy pattern in the lab in order to find out how energy can be saved. The paper is different from other in a way that it has also studies on user preferences regarding the idea of smart lighting. There are many work in progress doing and done by the university itself regarding lighting and energy saving system. The results have shown that nearly half of the energy can be saved for the lab. It has also mentioned that wireless structure is more cost-saving.

The next article chosen is written by A.A.Nippun Kumaar (2010) regarding Wireless Sensor Network (WSN). It focuses on using sensors to save energy by adjusting the brightness of light according to environment. It emphasizes on the usage of wireless network which is cheaper and easier to construct.

A.A.Nippun Kumaar, et al (2010) have examines the use of Wireless Sensor Networks (WSN) to control the brightness of Dimmable Fluorescent light to allow the usage of daylight substitution to reduce energy usage in existing buildings. It is a totally wire free system which claims to be easier and cheaper to be installed compare with normal wired structure system.

In the implementation, there is a series of light sensor nodes which communicate with a master node (MN), giving information about the light condition at each sensor node. The MN will utilize the information to decide which light sources to be control and transmit the data to the specific light control node. The network consists of three kinds of nodes, master node (MN), sensor node (SN), and light control node (LCN).

This wireless lighting control system utilizes two types of hardware, sensor node and light control node. One of the sensor nodes is chosen to be the main node which is installed with additional control software. The software uses consist of three forms, each in MN, SN and LCN respectively. Each form has its own algorithm to run the system.
The results of the study shows a moderate decrease in total energy consumption for the propose system.

The next article studied about the possible utilization of daylight in offices in Malaysia, which entitled "Investigating Daylight Quality in Malaysian Government Office Buildings through Daylight Factor and Surface Luminance" written by M. Z. Kandar et al. The research aims to find out the daylight quality in 5 different areas in Malaysia and also the design of the building that affects the ability of daylight utilization. Daylight quality is measured by few parameters, such as the daylight factor, surface luminance ratio and surface luminance. Daylight factor measure if the office space is suitable for daylight utilization or not. Surface luminance ratio measures how much the window is brighter than the internal surfaces. Surface luminance shows the brightness of surfaces.

The results show that most of the buildings are not designed to optimize daylight utilization. 100 percent of office buildings show that although external daylight is sufficient and available for use, electric lighting is still more preferable. This unhealthy situation is happening in UTP where window are actually transparent and thus in fact, daylight can be harvested.

CHAPTER 3
METHODOLOGY/PROJECT WORK

3.1 Research Methodology

The research methodology chosen is Rapid Application Development (RAD). The method is most efficient for the project because it enables quality products to be developed faster, saving resources and time.

Prototyping is used throughout the project, where part of the device and the website are made functional in order to be refined and tested regularly until completion.

The figure below depicts the phases under Rapid Application Development (RAD) methodology.

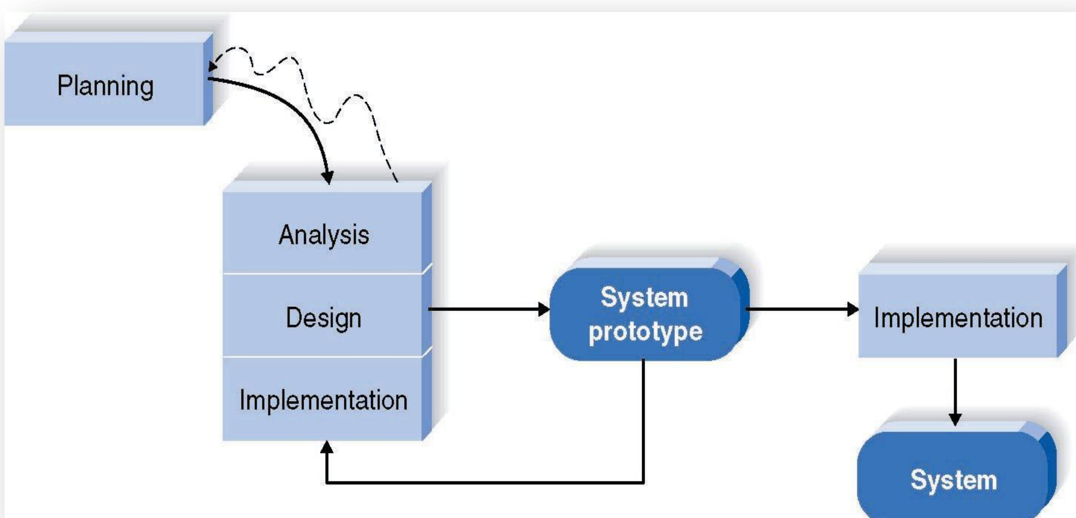


Figure 3.1.1: Rapid Application Development cycle.

The figure above shows the phases under Rapid Application Development (RAD) methodology. It has three phases:

1) Requirements planning
2) RAD design workshop
3) Implementation

Planning phase started by data collections. Activities such as survey and interviews are used to get the opinions of the whole education kit from the experts, users and other mediums. Lecturers in the related fields and technicians are approached and interview sessions have been carried out. Besides, research and studies of related topics are on-going since FYP 1.

In the next phase, analysis, design and implementation processes will begin. The device and the website are made and tested in this phase. The processes of enhancing and testing the systems are repeated until all the requirements are fulfilled. This phase is started during FYP 2 until the completion of the project.

The last phase is to implement the system. It is impossible to implement the lighting system right away after the prototype is completed. Thus, the prototype is tested instead to ensure it is fully workable. Estimations are done based on the lighting consumption pattern and previous data to drawn the results that could be produced by implementing the prototype. On the other hand, the website is functional and is uploaded and ready to be used anytime upon completion of the project.

3.2 Key Milestone

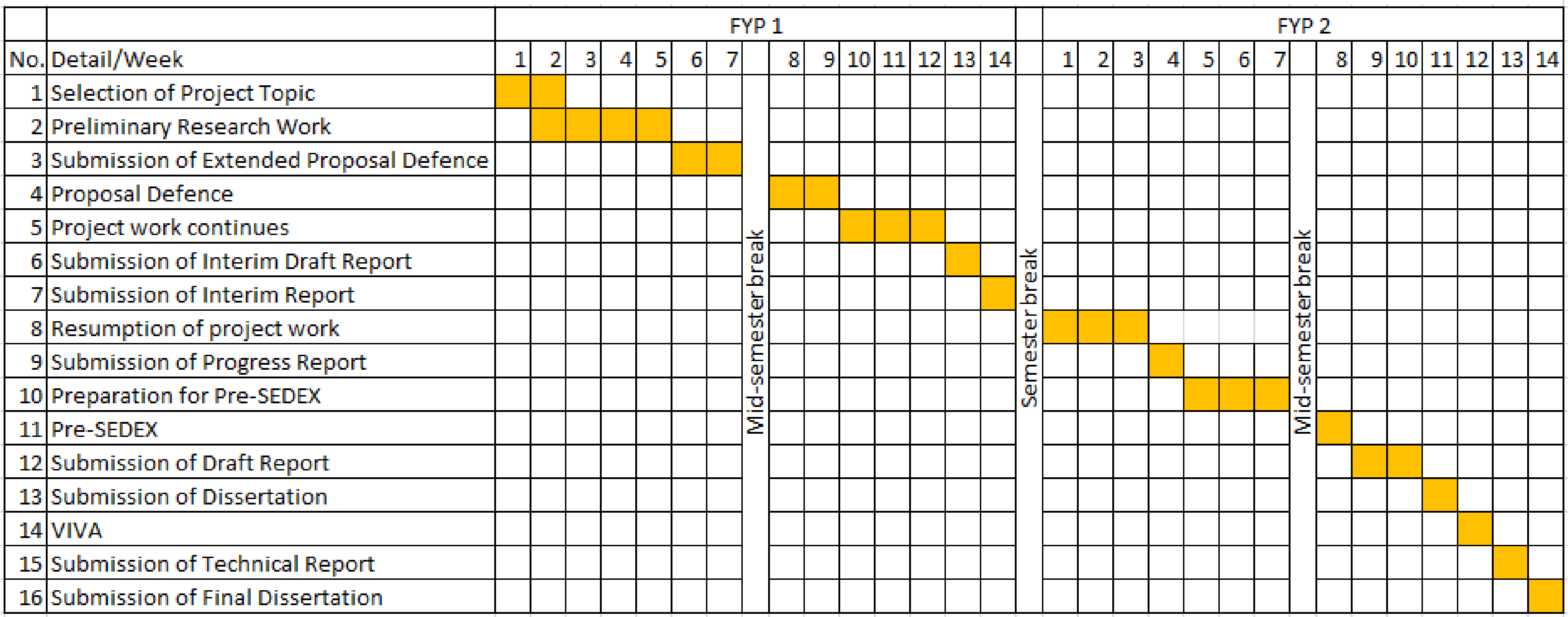


Figure 3.2.1 : Key Milestone

3.3 Gantt Chart

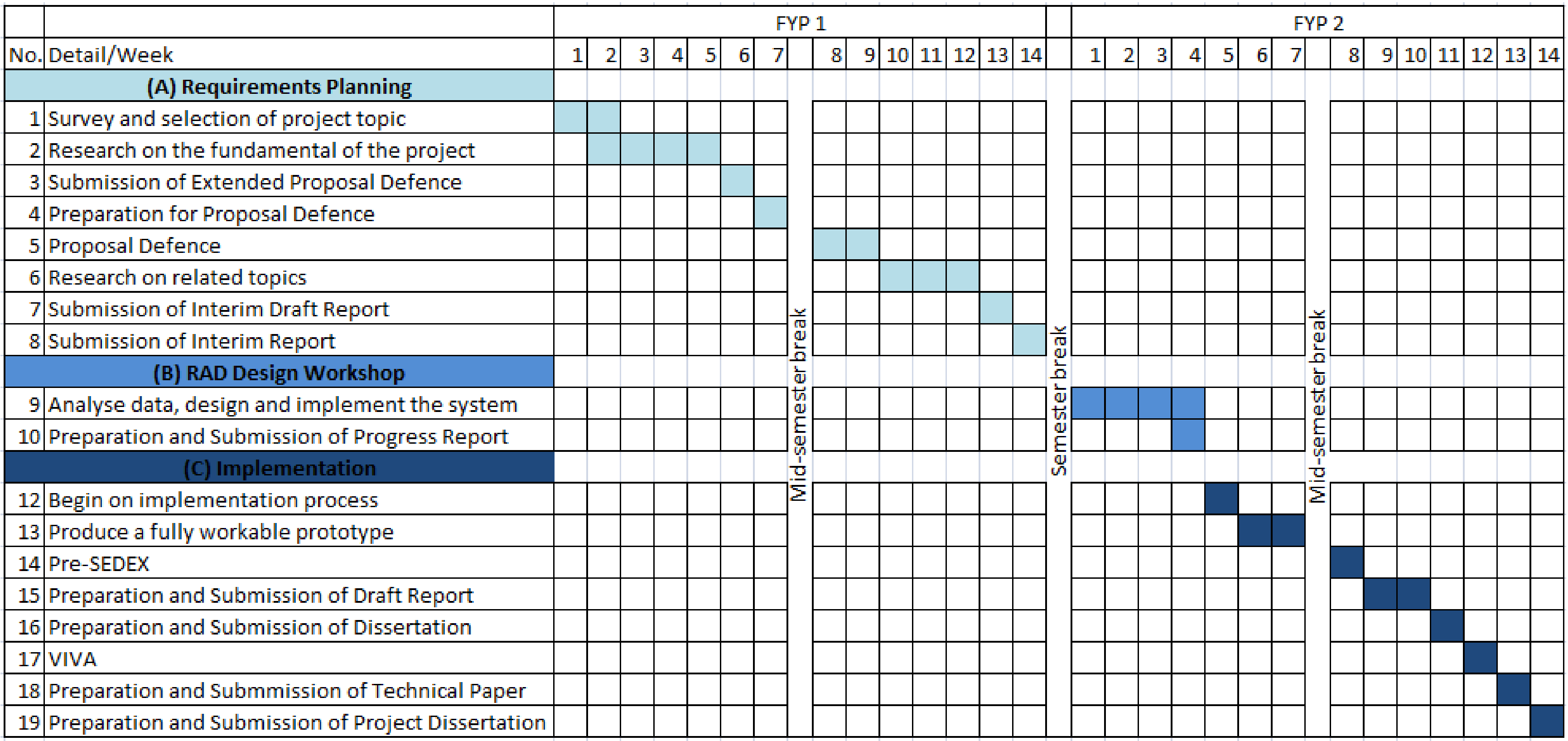


Figure 3.3.1 : Gantt Chart

3.4 Design Architecture for Prototype

Figure below shows the design and architecture or the circuit of the prototype. When the Passive Infrared (PIR) sensor detects a motion and light intensity sensor detecting low light intensity, the intelligent lighting system will be switch on, and vice versa.

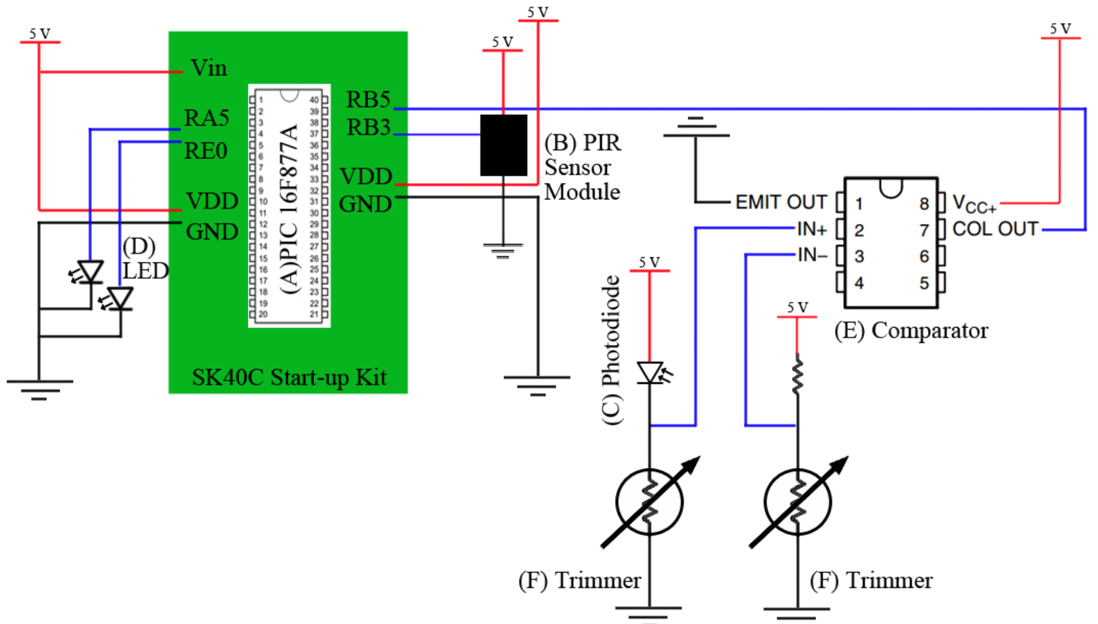


Figure 3.4.1 : Design architecture for prototype.

The program embedded in the system is written in C++. The software used to write the coding is MPLAB IDE version 8.30, while the software use by the programmer to program the microcontroller in this circuit is Picket2 version 2.61. These 2 softwares are essential to program the system. The following paragraphs will briefly describe the main components used in the circuit.

(a) PIC 16F877A

Figure below shows the PIC used in the circuit.

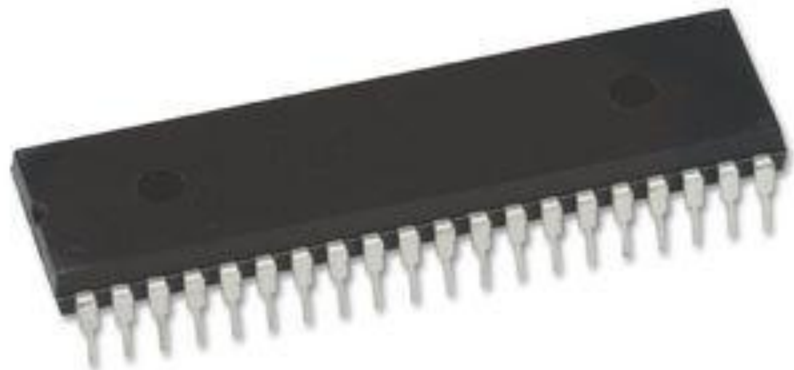


Figure 3.4.2 : PIC16F877A microprocessor.

PIC microcontroller means Peripheral Interface Controller. It is an electronic circuit that can be programmed to do a variety of task, for instance act as a timer. They are present in many electronic devices such as laptops and smart phones. In this system, the PIC microcontroller will be programmed accordingly to switch the light on and off responding to the light intensity sensor and the PIR sensor.

The model of PIC microcontroller selected is PIC16F877A with 40 pins. Its main features include 2 PWM 10-bit, 256 Bytes EEPROM data memory, ICD, 25mA sink, self programming and parallel slave port. This device is selected because it is efficient and recommended by electronic and electrical engineering student as the simplest to operate. It is impressive that it contains only 35 single-word instruction to write a program. Besides, the cost is low. More technical details can be found it its datasheet.

The programmer used to program the microcontroller is a USB PIC Programmer. It is compatible with windows and can be powered directly from USB port, thus it does not require an external power source. It comes with rainbow cable that can be connected to the green board, or the SK40C PIC Start-Up Kit where the microcontroller is fixed on top of it. SK40C has 40 pins so that it is compatible with the microcontroller. Its main function is to attach the microcontroller and to allow the programmer to program the microcontroller. It has provided with 2 LED indicators, 2 switches and other features which makes it easier to be used. Figures below show the programmer and the start-up kit.

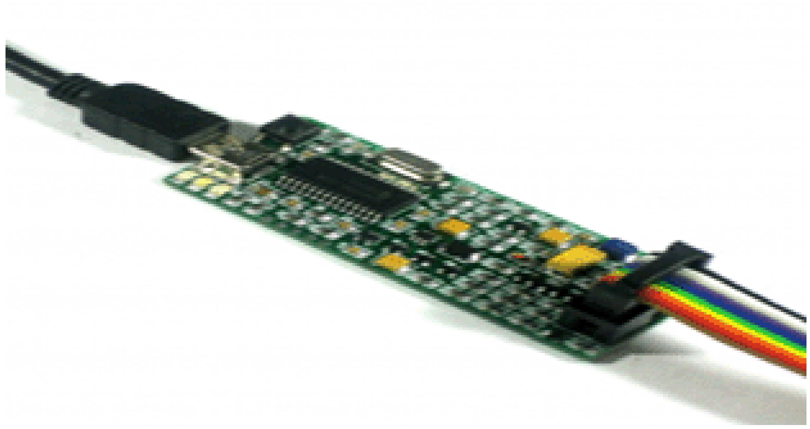


Figure 3.4.3 : USB PIC Programmer.

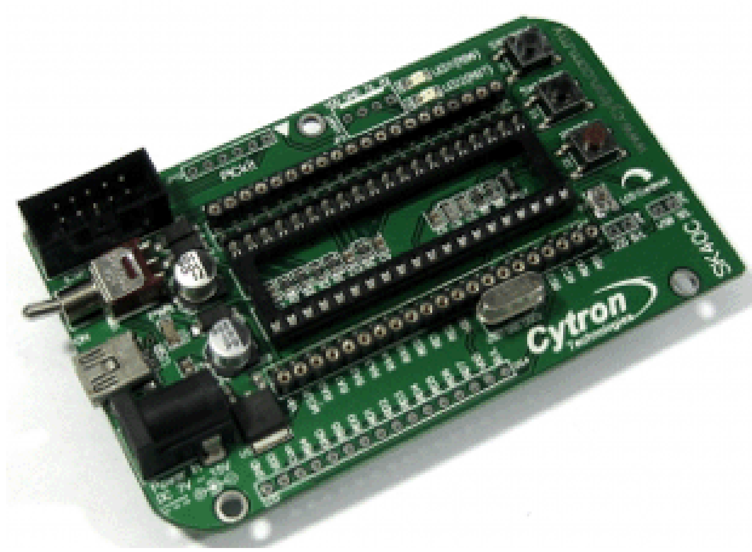


Figure 3.4.4 : SK40C Start-Up Kit.

(b) PIR sensor module

Figure below shows the PIR sensor module used in the circuit.

Figure 3.4.5 : PIR sensor module.

A PIR sensor is an electronic device that measures infrared radiated from an object in its vision field. Infrared is a radiation which exists in the electromagnetic spectrum and can be detected. It has a wavelength longer than visible light, thus it cannot be seen by human eyes. The sensor is passive because it does not generate and emit any form of radiation during detection. The function of PIR motion sensor usually is to detect intruders for residentials used.

The function of PIR sensor in the system architecture is used to detect motion triggerd by human. Any object that produces heat will also produce infrared radiation, same goes to human body. Different object has different amount of radiation. In order to differentiate human from other objects, such as animal, an infrared filter is placed in front of the sensor to increase sensitivity. Skin temperateure is around 34 degree celcius, which is higher than the background temperatures. When a person pass by, the higher temperature will create a higher charge in the pyroelectric material inside the sensor. The amplifier will boost the amount of the small signal. In order to detect human, the infrared filters wavelengths from 8 to 14 μm, since human body emits infrared energy at a wavelenth of 9 to 10 μm, The selected PIR sensor is PIR Sensor Module made by Cytron. It cost is reasonable especially compare with other products in the market. Cytron's PIR sensor is small in size make it easy to be conceal. It provides a big field of view which is 120 °. Besides, it is compatible with all types of microcontroller, thus it also compatible with the selected PIC16F877A microprocessor. It has "Plug n Play" features which makes it more flexible. More technical information can be found in its datasheet.

Photodiode

Figure below shows a Photodiode.

Figure 3.4.6 : Photodiode.

A light intensity sensor, also named as brightness sensor or ambient light sensor is an electronic device that used to detect light similar as the human eye. There are many different types of light sensors in the market. For example, photocell, a small sensor that changes its resistance once light shines on it. Other examples such as charged coupled device that transports electrically charged signals and photomultipliers that detect light and multipy it. Functions of light sensor are to save battery power, save energy, headlamp control in cars and automatic dimming of flat panel displays and instruments in automobiles. Uses of light sensors including in the alarm system, handphones, energy saving system, computers, televisions and many more devices.

In the prototype, the light sensitive component used is a photodiode. Its function is to detect light. Once light is detected, it will turn it into voltage. This voltage will be used to compare with the voltage set in the comparator. The program in the microcontroller will decide the action to do with the difference in the voltage.

(c) Light Emitting Diode (LED)

Figure below shows an LED.

Figure 3.4.7 : LED.

In the circuit, LED represents the real lamp. In the system, when it lights up, it idicates that motion is detected and light intensity in the surrounding is low. LED is a very durable lighting device which is small in size and be able to withstand severe weather. It is also environmental friednly where it does not contain any mercury or harmful chemical substance. Its cost is higher than normal flruorescent bulb but it is very long lasting.

(d) Comparator

The following figure shows the comparator used in the circuit.

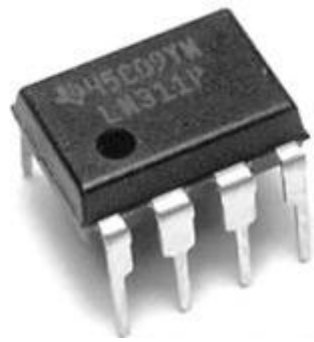


Figure 3.4.8 : Comparator.

The figure above shows a differential comparator used in the circuit. It is an open-collector which means it has the ability to ground its output to indicate a logic low, but it cannot drive its output high, thus it always require a pull up resistor to be fixed together with it. The main function of the comparator is to compare the voltage set as the threshold with the voltage given by the photodiode. It act as a component that receives the voltage reading from the photodiode and send the data to the microcontroller by indicating a logic high (1) or a logic low (0).

(e) Trimmer

The Figure below shows the trimmer used in the circuit.

Figure 3.4.9 : Trimmer.

Trimmer acts as a device to adjust the voltage or resistance in the circuit. One trimmer is used to adjust the input voltage of the photodiode, another trimmer is used to set the base voltage to compare with the input from the photodiode. It can be turn clockwise or anticlockwise using a skrew driver.

3.5 Design Architecture for Educational Website

The website is developed using online free hosting website software, wix html. The link to the website is: http://venicelegolas.wix.com/green-campus

The following paragraphs will show the main pages which made up the website.

Figure below shows the home page of the website.

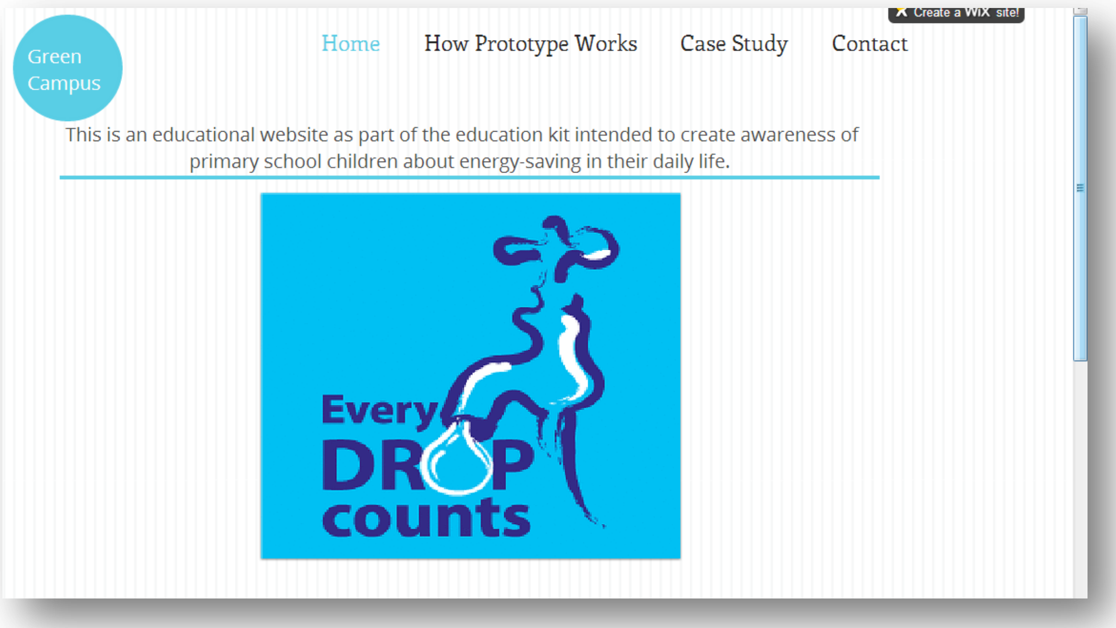


Figure 3.5.1 : Home page for educational website.

The home page will explain to the readers about what is the importance of preserving the environment. It also shows the steps that can be taken to reduce the negative impact of human activities towards the environment during daily life.

The figure below shows the second page, which explains how the prototype works.

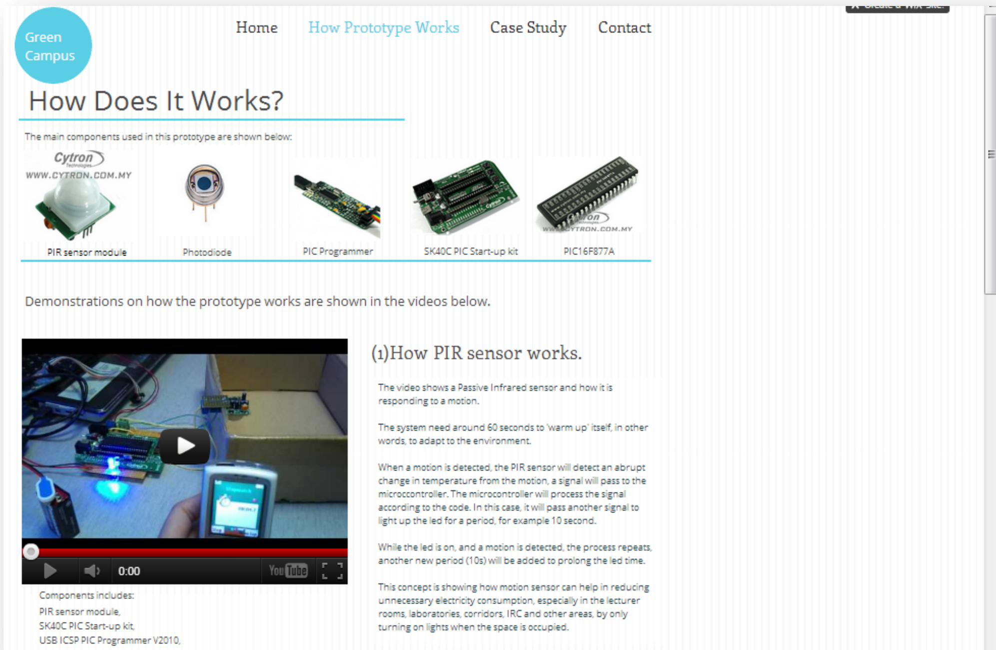


Figure 3.5.2 : Webpage explaining about how the prototype works.

The second page explains about how the prototype in the education kit works to the users. It contains introductions to the component used and several videos on how the PIR sensor and the photodiode work. It also shows the video on how the whole prototype works. It provides easy to understand explanations, without using any jargon or difficult terms, thus making it suitable for user especially children who does not have electronic background to comprehend it.

Figure below shows the case study in the website.

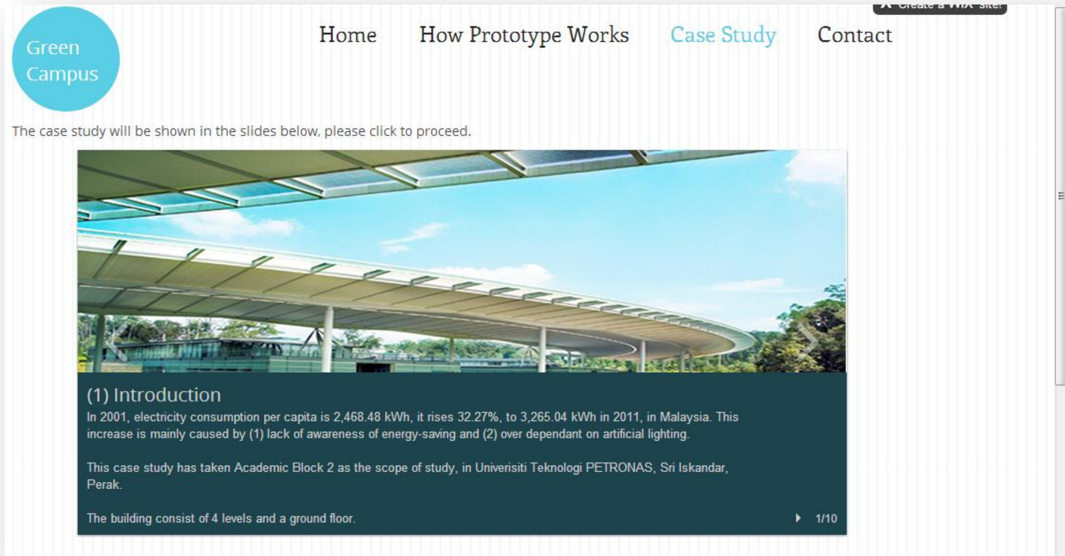


Figure 3.5.3 : Case study page.

The figure above shows the case study page taken from the website. The case study contains introduction, objective, problem statement, methodology, design architecture, results and discussion and conclusion. It is presented in slide, where users have to click to proceed. Every slide has a picture to support, so that it will be more interesting to the reader.

Figure below shows the last page of the contact page in the website.

Figure 3.5.4 : Contact page.

The website also provides a contact page for user to show their feedback, so that improvement can be made later if necessary. Besides, it also contains a comment box for user to interact with each other, thus, making the website more interactive. Figure below shows the comment box in the website.

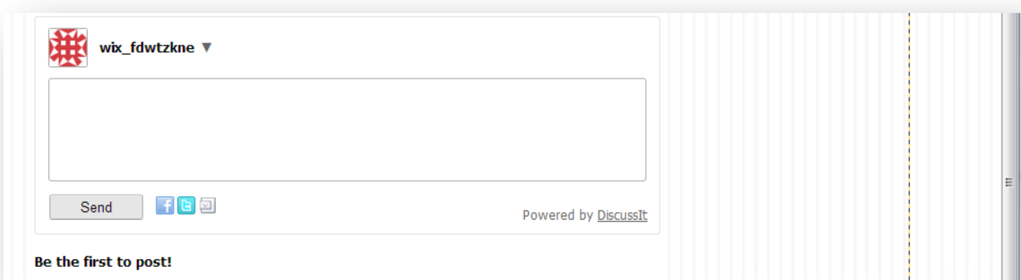


Figure 3.5.5 : Comment box in the website.

CHAPTER 4
RESULTS AND DISCUSSION

This section will discuss the case study regarding to the UTP electricity consumption on lighting in Academic Building 2.

4.1 UTP Electricity Consumption

The bar chart below shows the annual total electricity consumption in UTP from January year 2010 until May 2012. The y axis shows the electricity consumption in kWh. The x axis shows the months within the years.

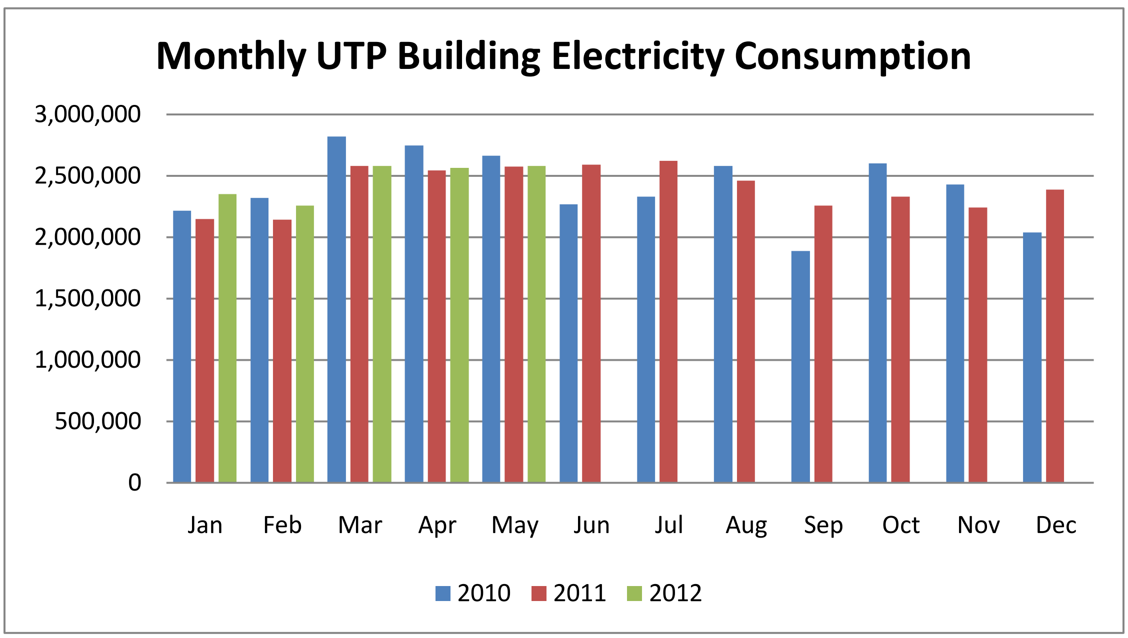


Figure 4.1.1 : Bar chart of monthly UTP building electricity consumption from January year 2010 until May 2012.

The table below shows the summary of UTP annual electricity consumption for year 2010, year 2011 until May 2012.

Year	Total Energy Consumption (kWh)
2010	28,881,072
2011	28,862,131
2012(Until May)	12,327,528

Table 4.1.1 : Summary of Annual Total Electricity Consumption of year 2010, 2011 and until May 2012.

4.2 UTP Electricity Consumption Rating

The figures given can be used to measure the Building Energy Index (BEI), to see if the building is spending electricity wisely. Total energy used is calculated in kWh. The total area is calculated in sq m/year. The formula of BEI is shown below.

$$Building\ Energy\ Index\ (BEI) = \frac{Total\ Energy\ Used}{Total\ Area}$$

The total energy used in year 2011 is inserted into the formula, however, the total area is unknown, as shown in below.

$$Building\ Energy\ Index\ (BEI) for\ year\ 2011 = \frac{28{,}862{,}131}{Total\ Area}$$

From the paper written by M.F. Khamidi et al, BEI of UTP for the year 2007 is 287kWh/m^2. From the same paper, it has shown that total electricity consumption in year 2007 is 26,629,550 kWh. Thus the area can be found as follows.

$$287 = \frac{26{,}629{,}550}{Total\ Area}$$

$$\text{Total Area} = \frac{26{,}629{,}550}{287}$$

Total Area = 92,785.8885m^2

According to M.F. Khamidi, this total area is comprises of confined area, for instance in a lecturer office, lecture room, washroom. Places such as corridor, basketball field, and street lights are not included in the calculation.

Thus,

$$Building\ Energy\ Index\ (BEI) for\ year\ 2011 = \frac{28{,}862{,}131}{92{,}785.8885}$$

BEI in 2011 = 311 kWh/sq m/year

According to Ar V. K. Leong (2010), the energy efficiency of existing buildings in terms of BEI in Malaysia can be seen in the figure below.

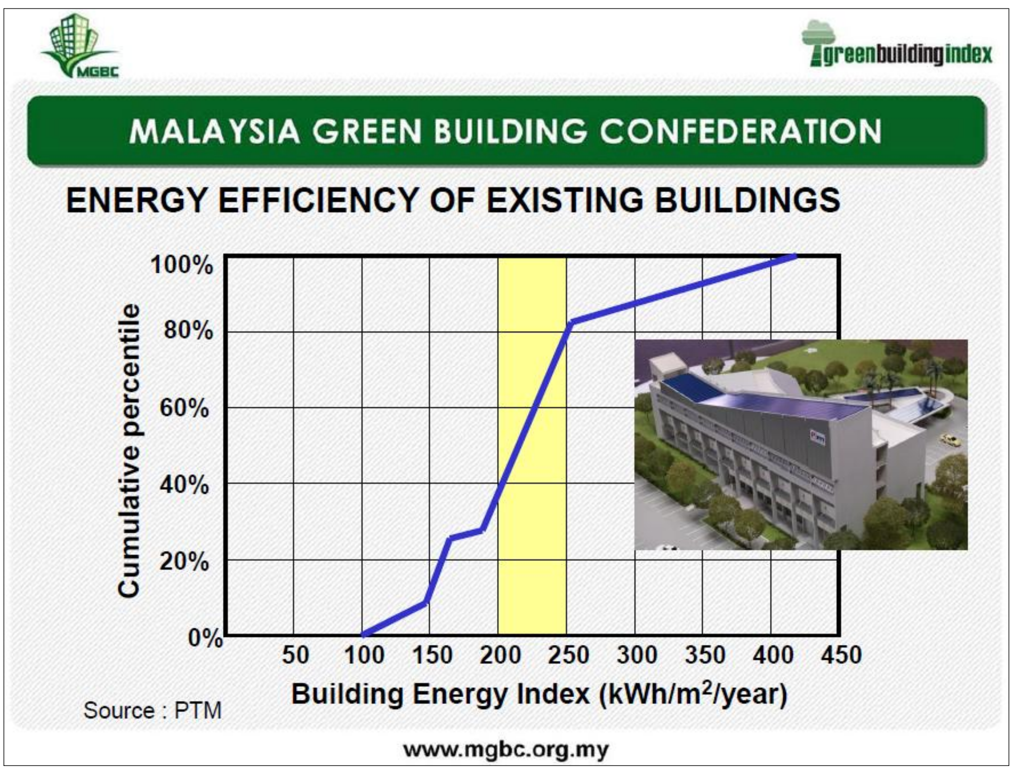


Figure 4.2.1 : The energy efficiency of existing buildings in Malaysia.

From the figure above, the average Malaysian buildings have BEI of between 200 and 250 kWh/m^2/year. However, UTP BEI is 311 kWh/m^2/year in year 2011, which is shown in the following figure.

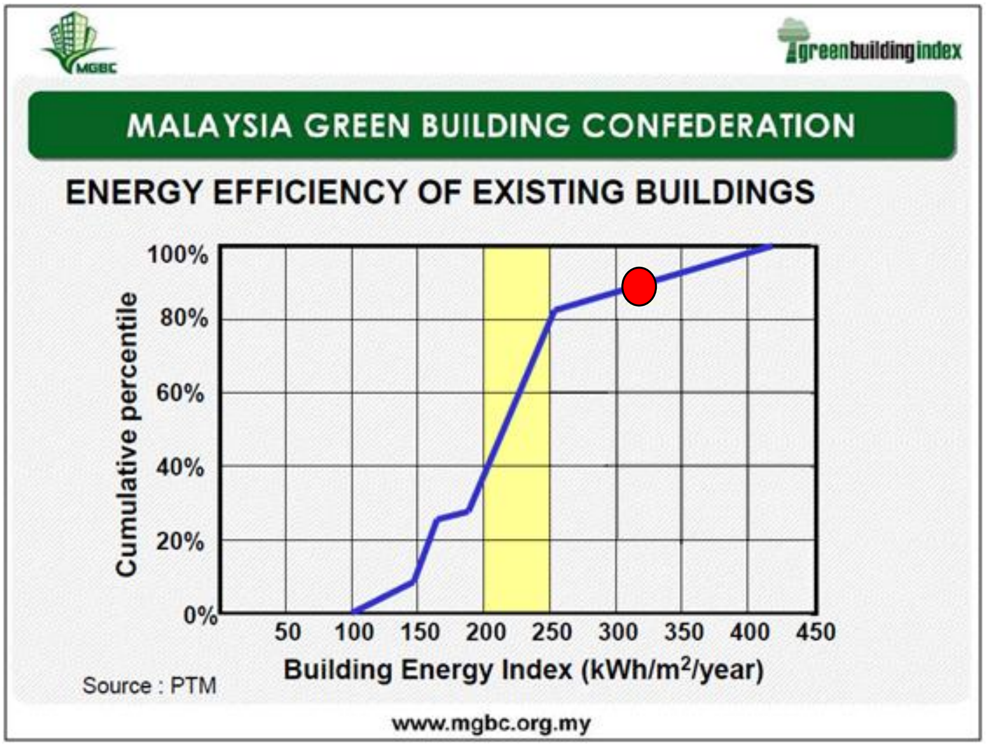


Figure 4.2.2 : UTP BEI on the overall graph.

From the figure above, UTP BEI is over the average range of BEI compare with other buildings in the country. It is not consuming electricity as efficient as the average buildings in the country.

Green Building Index (GBI) is a green rating system introduced by the Pertubuhan Arkitek Malaysia (PAM) to evaluate the performance of building across a broad range of environmental considerations. These considerations include the Energy Efficiency of equipment used in the office, indoor environmental quality, sustainable site planning and management, materials and resources, water efficiency and innovation. UTP building is rated based on the aspect of Energy Efficiency only, since the main focus of this study is on the overuse of electricity, especially in lighting.

From T. L. Chen (2012), GBI rating is shown as the following table.

Green Building Index Rating	Average M'sian Bldg	Meets MS1525	GBI Certified	GBI Silver	GBI Gold	GBI Platinum
BEI kWh/m2.year	250	200 - 220	150 - 180	120 - 150	100- 120	<100
Energy Savings %	Base	10 - 20	30 - 40	40 -50	50 – 60	> 60
Incremental construction cost %	Base	1 – 3 (0 – 3)*	5 – 8 (1 – 5)*	8 – 12 (3 – 8)*	12 – 15 (5 – 10)*	>15 (6 – 13)*

Table 4.2.1 : GBI rating, energy savings and incremental construction cost respectively.

As shown in the table, UTP BEI of 311 is far from being rated as a green building. As a technology oriented university, UTP is not even qualify to be rated as a green building. The table also shows the percentage of energy savings when the building is meeting certain GBI. The last row of the table shows the incremental construction cost in percentage that depicts that the greener the building, the higher the incremental construction cost required to construct a building. However, these figures have been reviewed in year 2011 and written in red and are shown to be reduced.

There is much to be done in order to reduce the electricity wastage in the university. Before achieving any green building rating, it is advisable for the university to set an aim to reduce its BEI year by year, for the sake of the environment.

4.3 Analysis of Electricity Consumption of Lighting in Academic Building 2

One academic building is selected as sample to represent the overall electricity consumption pattern in the campus. The scope of study is classrooms in Academic Building 2, from ground floor to second floor. 3rd floor is omitted because it consist of offices for lecturers. Following pages will demonstrate the estimations of lighting spending pattern in Academic Building 2, for all the classrooms which are accessible by students during their whole studies.

The rooms related to the study are Application Laboratories, Data Communication Laboratory, Multimedia Laboratories, Seminar Room, and Discussion Room. These are the rooms used for teaching and learning purpose and typically, most electricity is spent on these rooms. Interested columns and rows are highlighted. Hours used per week for each classroom is taken from the university website. Empty data represents unavailable data from the website.

All the lighting in ground floor, Academic Building 2 is analyzed as shown in the table below.

Room number	Name	Type and Number of Lamp Used		Hours used per week (hours)	Estimated electricity required per week (kWh)
		2x36 W (4 ft) (72 W)	2x18 W (2 ft) (36 W)		
02-00-02	Technician Room	3	1	10	
02-00-03	Application Laboratory 6	30	5	-	-
02-00-05	Application Laboratory 5	30	5	19	44.46
02-00-06	Application Laboratory 4	30	5	0	0
02-00-07	Application Laboratory 1	30	5	14	32.76
02-00-08	Technician Room	2	1	-	-
02-00-10	Application Laboratory 2	30	5	12	28.08
02-00-11	Application Laboratory 3	30	5	-	-
AHU-2-00-1	Plant Room	-	-	-	-
AHU-2-00-2	Plant Room	-	-	-	-
		1x18 W PLC lamp	2x18 W PLC lamp		
Female toilet	Female toilet	10	-	-	-
Male toilet	Male toilet	10	-	-	-
Corridor	Corridor	-	71	-	-

Table 4.3.1 : Type and number of lamp used and estimated electricity required per week at ground floor, Academic Building 2.

It is estimated that the current consumption of lighting in Academic Building 2 is 10 hours per day, from 8am to 6pm. The required consumption is the consumption needed for class hours.

Estimated Current Consumption		Required Consumption
2x36 W = 72 W	2x18 W = 36 W	44.46 + 32.76 + 28.08 = 105.3 kWh per week
72 W x (30 x 6) = 72 W x 180 = 12,960 W	36 W x (5 x6) = 36 W x 30 = 1,080 W	
(12,960 W + 1,080 W) x 10 hours / 1000 = 140.4 kWh per day		
140.4 kWh x 20 days = 2,808 kWh per month		105.3 kWh per week x 4 = 421.2 kWh per month

Table 4.3.2 : Estimated current consumption and required consumption of electricity per month at ground floor, Academic Building 2.

Electricity consumed in classrooms in ground floor, Academic Building 2 for a month during working days is estimated to be 2,808 kWh. The required consumption is only 421.2 kWh per month, the excess electricity spent can be calculated as follows.

$$\frac{(2{,}808 - 421.2)}{2{,}808} x\ 100 = 85\%$$

All the lighting in first floor, Academic Building 2 is analyzed as shown in the table below.

Room number	Name	Type and Number of Lamp Used		Hours used per week (hours)	Estimated electricity required per week (kWh)
		2x36 W (4 ft) (72 W)	2x18 W (2 ft) (36 W)		
02-01-02	Data Communication Laboratory	33	5	6	15.34
02-01-04	Technician Room	3	1	-	-
02-01-08	Multimedia Laboratory 5	30	5	16	37.44
02-01-09	Multimedia Laboratory 4	30	5	12	28.08
02-01-10	Multimedia Laboratory 1	30	5	14	32.76
02-01-13	Multimedia Laboratory 2	30	5	13	30.42
02-01-14	Multimedia Laboratory 3	30	5	4	9.36
AHU-2-01-1	Plant Room	-	-	-	-
AHU-2-01-2	Plant Room	-	-	-	-
		1x18 W PLC lamp	2x18 W PLC lamp		
Female toilet	Female toilet	10	-	-	-
Male toilet	Male toilet	10	-	-	-
Corridor	Corridor	-	61	-	-

Table 4.3.3 : Type and number of lamp used and estimated electricity required per week at first floor, Academic Building 2.

The same estimation is also used to calculate the lighting spending pattern for first floor.

<table>
<tr><td colspan="2">Estimated Current Consumption</td><td>Required Consumption</td></tr>
<tr><td>2x36 W = 72 W</td><td>2x18 W = 36 W</td><td rowspan="3">15.34+ 37.44 + 28.08 + 32.76 + 30.42 + 9.36
= 153.4 kWh per week</td></tr>
<tr><td>72 W x (33+(30x5)) = 72 W x183
= 13,176W</td><td>36 W x (5 x 6) = 36 W x 30
= 1,080 W</td></tr>
<tr><td colspan="2">(13,176W + 1,080 W) x 10 hours / 1000 = 142.56 kWh per day</td></tr>
<tr><td colspan="2">142.56 kWh per day x 20 days = 2,851.2 kWh per month</td><td>153.4kWh per week x4 = 613.6kWh per month</td></tr>
</table>

Table 4.3.4 : Estimated current consumption and required consumption of electricity per month at first floor, Academic Building 2.

The electricity consumed in classrooms in first floor, Academic Building 2 for a month during working days is estimated to be 2,851.2 kWh. The required consumption is 736.272 kWh per month. The estimated unnecessary electricity spent can be found out as follows.

$$\frac{(2{,}851.2 - 613.6)}{2{,}851.2} x\ 100 = 78.48\%$$

All the lighting in second floor, Academic Building 2 is analyzed as shown in the table below.

Room number	Name	Type and Number of Lamp Used		Hours used per week (hours)	Estimated electricity consumed per week (kWh)
		2x36 W (4 ft) (72 W)	2x18 W (2 ft) (36 W)		
02-02-02	Usability Store Room	12	2	-	-
02-02-03	Usability Laboratory	1	1	-	-
02-02-06	Usability Control Room	4	1	-	-
02-02-08	Usability Waiting Room	6	1	-	-
02-02-09	Virtual Reality Laboratory 1	-	-	4	-
02-02-10	Server Room	4	1	-	-
02-02-12	Post Graduate Room	42	7	-	-
02-02-13	Seminar Room	18	3	19.5	27.378
02-02-14	Voice Over IP (VoIP) Research Lab	6	1	-	-
02-02-15	Multimedia Laboratory 6	30	5	4	9.36
02-02-16	Discussion Room	12	1	23	20.7
AHU-2-01-1	Plant Room	-	-	-	-
AHU-2-01-2	Plant Room	-	-	-	-
		1x18 W PLC lamp	2x18 W PLC lamp		
Female toilet	Female toilet	10	-	-	-
Male toilet	Male toilet	10	-	-	-
Corridor	Corridor	-	34	-	-

Table 4.3.5 : Type and number of lamp used and estimated electricity required per week at second floor, Academic Building 2.

If all the lights in Seminar Room, Multimedia Laboratory 6 and Discussion Room have been switched on for 10 hours, from 8am to 6pm, the estimated electricity consumption and required consumption are shown in the table below.

<table>
<tr><td colspan="2">Estimated Current Consumption</td><td>Required Consumption</td></tr>
<tr><td>2x36 W = 72 W</td><td>2x18 W = 36 W</td><td rowspan="3">27.378 + 9.36 + 20.7
= 57.438 kWh per week</td></tr>
<tr><td>72 W x (42+18+30+12)= 72 W x 102 =7,344 W</td><td>36 W x (7+3+5+1) = 36 W x 16
= 576 W</td></tr>
<tr><td colspan="2">(7,344 W + 576 W) x 10 hours / 1000 = 79.2 kWh per day</td></tr>
<tr><td colspan="2">79.2 kWh x 20 days = 1,584 kWh per month</td><td>57.438 kWh per week x 4 = 229.752 kWh per month</td></tr>
</table>

Table 4.3.6 : Estimated current consumption and required consumption of electricity per month at second floor, Academic Building 2.

Electricity consumed in classrooms in second floor, Academic Building 2 for a month during working days is estimated to be 1,584 kWh. The real consumption is estimated to be 229.752 kWh per month. The estimated extra electricity spent can be calculated as follows.

$$\frac{(1{,}584 \; - 229.752)}{1{,}584} x \; 100 = 85.5\%$$

All the data are tabulated as shown in the table below.

Floor	Estimated Current Consumption, kWh per month (10hours)	Required Consumption, kWh per month	Potential amount of energy saved (%)
Ground floor	2,808	421.2	85
First floor	2,851.2	613.6	74.18
Second floor	1,584	229.752	85.5
Total	7,243.2	1,264.552	82.54

Table 4.3.7 : Summary of estimated current electricity consumption and required consumption per month in Academic Building 2.

First part of the studies aimed to explain how much electricity can be reduced by using a PIR motion sensor. By fixing a PIR motion sensor, lights will only be switch on when required. It can help to saved up to 82.54% of electricity in Academic Building 2. By retrofitting the current lighting system with PIR sensor and light intensity system, it could help reduce unnecessary energy consumption in a long run. It benefits the environment as well.

However, the calculation uses 10 hours could be unrealistic, because not all lights in every room are open for these hours. It is because students and staff will switch on and switch off lights freely at all time. Thus, 10 hours is used as a benchmark for calculations. Also, it is stated by a senior technician in Academic Building 2 that the lights will be open from 8am in the morning until 6pm in the evening. However, according to observations, lights are on and off irregularly. If there are special booking by lecturer or events, the consumption could be different. It can be more or less than 10 hours.

In order find out the electricity spending pattern in Academic Building 2 and also to increase the accuracy of the studies, the previous year data are used as reference. Table below shows the real total electricity consumption of lighting in Academic Building 2 on year 2011.

Block	KWH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
B02	SSB CB01	0	22100	26400	27273	117865	51289	26727	27709	19229	23110	26606	25144	393452

Table 4.3.8 : Electricity consumption of lighting in Academic Building 2 on year 2011.

According to Senior Executive from Property Management & Maintenance UTP, the estimated amount of electricity spent on lighting is 20% out of total consumption. Assumed that, the electricity spending pattern on lighting is similar for this year, the data are used to estimate the electricity spent on lighting this year, for every month. The calculations are shown below.

Total consumption = 393,452 kWh / 12 months
= 32,787.67 x 20% on lighting
= 6,557.53 kWh per month

The focus of the study does not include 3rd floor, thus it must be excluded. Below shows the estimated total hours of lighting used in Academic Building 2, except 3rd floor, in a month.

Total consumption = 6,557.53/4 = 1,639.38 kWh per floor
= 1,639.38 x 3
= 4,918.15 kWh for ground, first and second floor

Derived from the earlier calculations, energy used per hour for all lights is 724.32 kWh. Among all these lights, 30% will be allocated as consumption for other non-classrooms such as technician rooms, utilities rooms, corridors and toilets.

Non-classroom (exclude 3rd floor)	kWh
Toilet	60 units x 18 W = 10.08 x 10 hours per day / 1000 = 10.80 x20 days = 216 kWh per month
Corridor	166 units x 36W = 5,976 x 5 hours/1000 = 29.88 x 20 days = 597.6 kWh per month
Others	41 units x 72W + 10 units x 36W = 3,312W x 10hours/1000 = 33.12 x 20 days = 662.4
Estimated Total kWh per month	30% = 1,476 kWh per month

Table 4.3.9 : Electricity consumption in non-classrooms.

Thus, the remaining will be the consumption used in classrooms. The calculations are as shown below.

4,918.15 x 70% = 3,442.71 kWh.

It can be used to calculate about how many hours all lights are being turn on in the classrooms to yield the same result. The calculation is shown as follows.

$$\frac{3{,}442.71 \text{ kWh per month}}{724.32 \text{ kWh per hour}} = 4.75 \text{ hours}$$

Classroom lightings are estimated to be used for 4.75 hours everyday. In order to be more realistic, a 10% of energy is added to the required consumption, representing the extra hours used by specials events and booking by lecturers for special classes. The following table will show the data in month.

Floor	(a)Estimated classroom lighting used per month, for each floor. (kWh) (4.75 hours)	(b)Estimated required consumption per month (kWh). 10% added for special events	(c) = (a-b)/ a x 100% Possible amount of energy saved per month, with PIR sensor (%).
Ground floor	1,333.8	463.32	65.26
First floor	1,354.32	674.96	50.16
Second floor	752.4	252.727	66.41
Total	3,440.52	1,391.0	59.57

Table 4.3.10 : Estimated amount of electricity saved by using a PIR motion sensor in classrooms.

The data above represents the estimated amount of electricity reduced by fixing a PIR motion sensor. Approximately 59.57% of current consumption can be reduced by a PIR motion sensor. In every floor, it can help to reduce consumption from 50.16% to 66.41%.

4.4 Light Intensity in Laboratory Academic Building 2

The study on the brightness in the lecture room is carried out in Data Communication Laboratory, in Academic Building 2. The light intensity of the classroom is measured for 4 days, from 26 October 2012, to 29 October 2012. Two light meters are used for the experiment. The first light meter is put on 3 meters from the light source and the second light meter is put on 6 meter from the centre of the light source. The light source here refers to the windows plane in the laboratory.

Figure below shows the results of the light meter that located 3 meters from the light source.

Light Intensity in Data Communication Laboratory for 4 Consecutive Days.

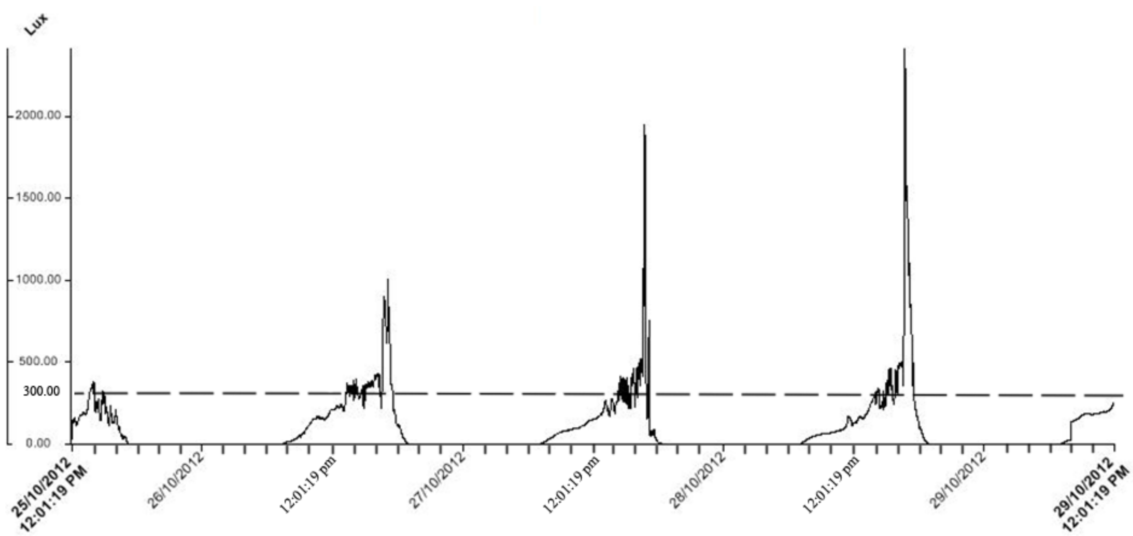


Figure 4.4.1 : First light meter's readings showing light intensity in Data Communication Laboratory for 4 continuous day.

According to the results, the highest value measured is 2,414 Lux while the lowest is 0 Lux, and the average is 98.398 Lux. The highest reading taken on day 3, 28 October 2012, 4:40:19 pm, while lowest reading happens after the sun goes down. The dotted line represents hours with 300 Lux and above. 300 Lux is the standard brightness for classroom and library according to the Malaysian Standard (2007). Thus, it shows a potential of daylight harvesting in the experiment area. Figure below shows the results of the second light meter that are located 6 meters from the light source.

Light Intensity in Data Communication Laboratory for 4 Consecutive Days.

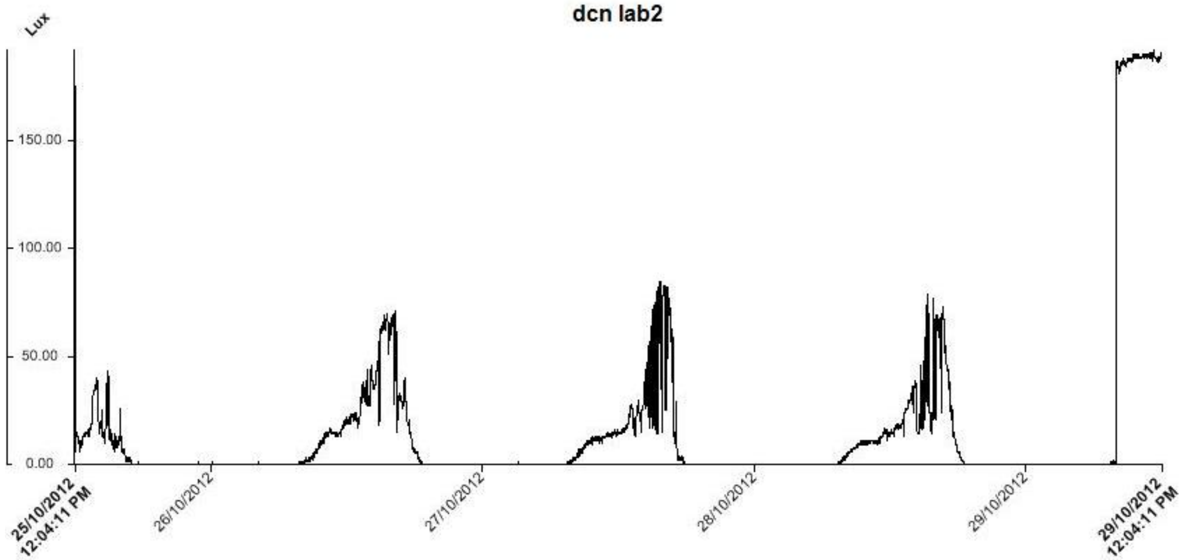


Figure 4.4.2 : Second light meter’s readings showing light intensity in Data Communication Laboratory for 4 continuous day.

According to the results, the highest value measured is 192 Lux while the lowest is 0 Lux, and the average is 16.31 Lux. The highest reading taken on day 4, 29 October 2012, 11:19:1 am. The overall reading is low compare to the first light meter because it is far from the light source.

Through observations, the readings are taken in rainy days. If it is taken during sunny day, the intensity will surely be higher. However, it is manage to prove that daylight is sufficient to light up the classroom during certain period. The data shows that light intensity is high from 1pm to 5pm. However, it is fully dependant on the weather. Besides, the orientations of different classroom also will yield different results. However, it is undeniable that, the new academic block is capable to utilize daylight because the window plane is transparent, and the light diffuses into the classroom does not contain glares. Thus, daylight has a high potential to be harvested.

The light intensity sensor is able to reduce the required electricity consumption. If the amount is estimated to be 25%, the required consumption will be reduced and the percentage of saving will increase. This can be shown in the calculations below.

Floor	(a)Estimated classroom lighting used per month, for each floor. (kWh) (4.75 hours)	(b)Estimated required consumption per month (kWh). 10% added for special events. 25% removed from light intensity sensor	(c) = (a-b)/ a x 100% Possible amount of energy saved per month, with PIR sensor (%).
Ground floor	1,333.8	347.49	73.95
First floor	1,354.32	502.22	62.62
Second floor	752.4	189.55	74.81
Total	3,440.52	1,043.25	69.68

Table 4.4.1 : Estimated amount of electricity saved by using PIR motion sensor and light intensity in classrooms.

The assumption shown in the above table shows that 25% will be reduced from required consumption. This estimation can be supported by several explanations. The percentage could be even higher for rooms which are highly exposed to sunlight, and lower at certain classrooms with lower exposure. Besides, daylight harvesting can help reduce heat and glare produced by artificial lights, those save electricity used to cool down the heat produced (M.F. Khamidi et al).

The pie chart below shows the estimated total electricity consumption for lighting in Academic Building 2.

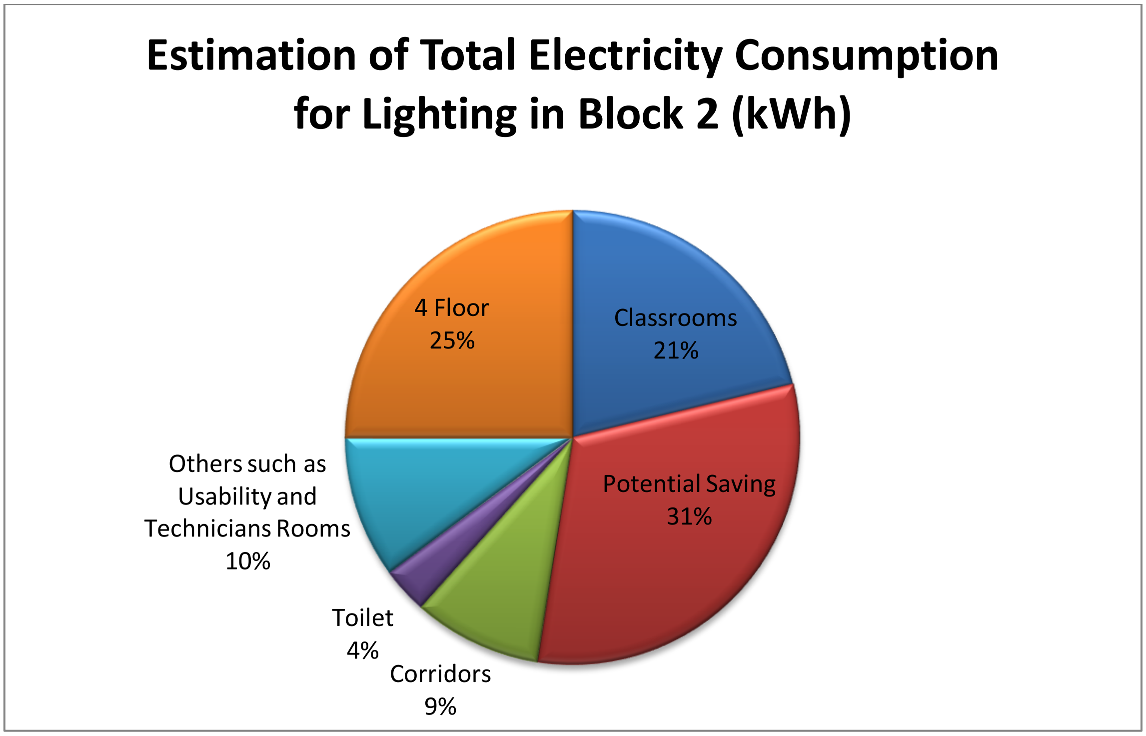


Figure 4.4.3 : Estimation of total electricity consumption for lighting in Academic Building 2.

The pie chart above shows the estimated percentage of electricity spent in whole Academic Building 2. It is expected that by using only PIR motion sensor, it is able to saved up to 31% of electricity for whole Academic Building 2, which is equivalent to 59.57% for all classrooms. After adding light intensity sensor, the energy require in classrooms will be reduced, by 25%, thus saving is estimated to increase to 69.68% for all classrooms, or equivalent to 36.58% for whole Academic Building 2. It is thus recommended that sensors should be used in lighting system in the Academic Blocks in order to reduce energy consumption.

4.5 Lighting Standard

Insufficient lighting will caused concentration to fall in the classroom. Thus, the brightness in a classroom is important in determining its productivity. There are some guidelines that can be followed to determine the right brightness in a classroom or lecture room.

The design of the window is crucial in order to harvest daylight, according to Malaysian Standard (2007). The purpose of daylighting should prevent direct solar radiation but allowing light to diffuse into the room space. The suggested daylight factor for an effective daylighting used in office space is 1.5 %. This calculation is come from the formula below.

$$Daylight\ Factor = \frac{E\ internal}{E\ external}\ X\ 100\ \%$$

The above formula shows the daylight factor, whereby the E internal represents the internal illuminance at a point in a room and E external, represents the instantaneous illuminance outside the building on a horizontal surface.

The value of daylight factors can be obtained by computer software stimulations or architectural modelling.

The table below shows the recommended average illuminance levels in different places, taken from the Malaysians Standard (2007).

Task	Illuminance (Lux)	Example of Applications
Lighting for infrequently used area	20	Minimum service illuminance
	100	Interior walkway and car-park
	100	Hotel bedroom
	100	Lift interior
	100	Corridor, passageways, stairs
	150	Escalator, travellator
	100	Entrance and exit
	100	Staff changing room, locker and cleaner room, cloak room, lavatories, stores.
	100	Entrance hall, lobbies, waiting room
	300	Inquiry desk
	200	Gate house
Lighting for working interiors	200	Infrequent reading and writing
	300 – 400	General offices, shops and stores, reading and writing
	300 – 400	Drawing office
	150	Restroom
	200	Restaurant, Canteen, Cafeteria
	150 – 300	Kitchen
	150	Lounge
	150	Bathroom
	100	Toilet
	100	Bedroom
	300 – 500	Class room, Library
	200 – 750	Shop / Supermarket/Department store
	300	Museum and gallery
Localised lighting for exacting task	500	Proof reading
	1000	Exacting drawing
	2000	Detailed and precise work

Table 4.5.1 : Recommended average illuminance levels.

Malaysian Standard (2007) data in the table above shows the recommended brightness in classroom falls in the range of 300 Lux to 500 Lux.

Other resources show different lighting requirement. For instance, The Standard Association of Australia specifies lighting levels as follows. The classrooms for general purpose only require 240 Lux of brightness.

AREA	ILLUMINATION LEVEL (LUX)
General purpose classrooms (at desks and blackboard)	240
Physical education class area Change rooms	240 80-100
Technical studies/computers	320
Science/home economics/music/art/trades	320
Assemble hall (auditorium areas)	100
Library reading areas Library shelves	320 240
Office and administration	320
Corridors, foyers	80

Table 4.5.2 : The Standard Association of Australia of lighting levels.

The Malaysian Standard also highlighted the maximum lighting power that should be consumed in a meter square in different places for different activities. The table below shows the unit lighting power allowance values recommended for different areas.

Type of Usage	**Max. Lighting power W/m^2**
Restaurants	15
Offices	15
Classrooms/ Lecture Theatres	15
Auditoriums/ Concert Halls	15
Hotel/ Motel Guest Rooms	15
Lobbies/ Atriums/ Concourse	20
Supermarkets/ Department Stores/ Shops	25
Stores/ Warehouses/ Stairs/ Corridors/ Lavatories	10
Car Parks	5

Table 4.5.3 : Unit lighting power allowance.

4.6 Alternatives for Current Light Bulb

According to H. Kara, lighting used in the laboratories in UTP are surface-mounted fluorescent luminaries with low-brightness louvers. The model of the light bulb used is PolyLux XL, model F18W/840/XLR and model F36W/840/XLR, which are made in Germany. Both models are efficient in a way that they produce 77 Lumen per watt and 94 Lumen per watt respectively. It is more efficient compare with the old conventional incandescent lamp that produces only an average of 14 Lumens per watt. The latter one uses up electricity to generate unnecessary heat which is unfriendly to the environment. Apart from that, it has an average of 15,000 life hours. It is also made of recyclable components. Besides, it contains less than 5mg mercury in every tube. However, a small amount of mercury is poisonous to the environment, thus it must be dispose properly at the end of usage. This is also why the more energy efficient fluorescent bulb is unable to make the old incandescent bulb obsolete due to this factor.

Apart from incandescent bulb and fluorescent bulb, the light emitting diode (LED) can be a better choice. This is because it is more environmental friendly whereby it does not contain mercury, which is meeting the ROHS standard. Studies have shown that LED has a longer lifespan with an average of 50,000 life hours which is higher than incandescent bulb and also fluorescent bulb with an average of 1,200 life hours and 8,000 life hours respectively. It is also small in size and thus making it durable to withstand difficult weather and be able to perform in almost any condition.

Apart from LED, in February 15, 2010, the sciencedaily.com has published an article announcing another energy-efficient lighting which does not contain any mercury. It is not LED. It is a technology that uses nanofiber-based reflectors and photoluminescent nanofibers to produce light. It is claimed to be able to generate 55 Lumens of light per watt consumed. Even it is not yet commercialized in the market, it possess another alternative to use less electricity to the user in the near future.

4.7 Cost of the Prototype

Below are the costs spent on building the education kit.

Direct cost:

Photo Diode	: RM 6.80
PIR sensor Module	: RM 22.00
Enhanced 40 pins PIC Start-Up Kit	: RM 39.90
USB PIC Programmer	: RM 50.90
Comparator	: RM 1.50
Trimmer	: RM 0.80 (2 units)

Total direct cost: RM 121.90

Indirect cost:

Other components such as vero boards, breadboard, wires are unable to be traced back, thus, the cost is around RM 121.90 to RM 150.

4.8 Performances of Energy Efficient Lighting with Sensors

Table below shows the potential energy saving percentage by using sensors in others studies. These data are used to validate the previous results estimated earlier in the study.

Area of research	Amount Reduced	Source
Potential energy saving from occupancy sensors. Private offices Classrooms Conference rooms Restrooms Corridors Storage areas	 13-15% 40-46% 22-65% 30-90% 30-80% 45-80%	US Environmental Protection Agency
Private Offices using occupancy sensor	20-46%	Jennings et al (2000)
Save various amounts using occupancy sensor. Restrooms Conference room Private office Break room Classroom	 20-64% 23-52% 13-40% 14-30% 26-60%	energysavingsensors.com
Daylight harvesting ballast for classrooms, offices, corridors, warehouses and factories	25-60%	DayTronic energy saving sensor
Occupancy saving sensor Daylighting	24% 28%	Analyses of 240 savings estimates from 88 papers and case studies, by A. Williams et al. (September 2011)
Energy saving from skylight and photo-control operation	20-30%	Reviews of Technical Reports on Daylight and Productivity, by P. Boyce. (2004)
Daylighting controls	16-50%	U.S. Department of energy, DOE Technical Assistance Program
Daylighting in school	18-46%	P. Plympton
Daylight control and occupancy sensor	45%	Design Lights Consortium

Table 4.8.1 : Potential amount of energy saving using sensors in others studies.

4.9 Usability Test

Usability Test on Intelligent Lighting System Education Kit is done. Table below shows the results of usability test done by 10 candidates, who are final year students in UTP.

Question 1: The characteristics below describe the design of the website. Please rate accordingly.

1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree

	Questions and number of responds	1	2	3	4	5
1	Fonts and numbering are clear and easy to read	-	-	-	3	7
2	The buttons and menus are clear and easy to locate	-	-	-	3	7
3	Easy to navigate from one page to another	-	-	-	3	7
4	Videos quality are good	-	-	-	3	7
5	The load time is acceptable	-	-	-	4	6
6	The overall design is appealing	-	-	-	3	7
7	The pages are up to date	-	-	-	3	7
8	It is user-friendly	-	-	-	3	7

Table 4.9.1 : Results of usability test question 1.

The first batch of questions asked the users about whether the website is user-friendly. Most of the users think that the fonts, numbering, buttons, menus, ease of navigation, videos quality and design are suitable. The users also agree that the website is up-to-date.

The load time of website depends on several factors. Other than the size of file in the website, the speed of loading of a website also depends on the internet connection on the user’s computer. Thus, it cannot fully be controlled by the website developer on the loading time of a website.

In conclusion, the overall results show that users like the general design and appearance of the website and all agreed that it is user-friendly to be used.

Question 2: The characteristics below describe the usefulness of the website. Please rate accordingly.

1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree

	Questions and number of responds	1	2	3	4	5
1	The information is helpful in educating children to be energy-saving	-	-	-	-	10
2	The videos are useful in explaining on how the prototype works	-	-	-	-	10
3	The case study is relevant to the topic	-	-	-	-	10
4	The way of presenting the case study is easy to understand for the children	-	2	4	4	-
5	The website is informative and important to be part of the education kit	-	-	-	-	10

Table 4.9.2 : Results of usability test question 2.

The second batch of questions study the users' experiences on whether the website is meeting its objective, which is to educate the children about energy-saving. All users strongly agreed that the information presented in the website is helpful and able to educate children to become more energy-saving. All users also fully agreed that videos are necessary in explaining to the children on how the prototype works. Besides, they also totally agreed that the case study is relevant and thus should be part of the education kit. All users have also agreed that the websites is informative and important to be part of the education kit.

However, some users think that the way of presenting the case study might not be easy for the children to comprehend. This is mainly due to the reason that children are never been exposed to case study. It seems to be complicated for the children. However, the case study is presented as slides. Each slide has a picture to support the explanations. In fact, the purpose of having the case study is to let the children know that sensors can be used to reduce the unnecessary electricity consumption in real situation. It is a scenario to represent other buildings in general.

Question 3: The following characteristics describe about the prototype. Please rate accordingly.

1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree

	Questions and number of responds	1	2	3	4	5
1	The prototype is able to attract attention of the children	-	-	-	1	9
2	The prototype must be accompany by the website	-	-	-	-	10
3	The prototype is important as part of the hands-on activities for children to engage in	-	-	-	-	10
4	The prototype is responding according to expected outcome	-	-	-	-	10
5	The prototype is easy to carry around due to its small size and light weight	-	-	-	1	9
6	The prototype is safe to be used as teaching material in school	-	-	7	-	3
7	The prototype is user-friendly	-	-	-	1	9
8	A prototype is preferable than textbook as an effective teaching material	-	-	-	-	10

Table 4.9.3 : Results of usability test question 3.

The third batch of questions aimed to investigate the users' opinions towards the prototype. All users totally agreed that, the prototype must come together with the website, because it is important as part of the hands-on activities tool in the education kit. All users also fully agreed that using a prototype to teach children is better than using typical textbook. All users have also responded that the prototype is showing the expected outcome.

Almost all users agreed that the prototype is attractive to the children and it is portable and easy to carry around. They also think that the prototype is user-friendly.

However, results show that 70% out of all respondents have no comment about the safety of the prototype. 30% of the respondents think that it is definitely safe to be used as teaching material. This group of people probably understand that, children should be always supervised by teachers or guardian when using any electronic devices. Further, it is made up of materials that are not harmful to the users. Thus, it should not be a concern to the users.

CHAPTER 5
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The industrialization and advancement of technology has brought many conveniences to human being, however it produces side effects that pollute the environment which is also affecting the lives of many. Problem such as overuse of electricity has caused the atmosphere to change, mostly negatively. The root cause of the problem is the ignorant human behaviour of their responsibilities towards the environment. Thus, in order to cope with this issue, education is necessary. The education kit presented in this study aims to increase the awareness of primary school children about the importance of energy-saving. The package consists of an education website, a lighting device as a prototype and a case study. The website consists of useful information and videos as the source of material for teachers to teach the children. The website explains about the importance of energy-saving and on how the prototype works. The prototype is the hands-on material students can play with while learning. The case study is used as a sample to represent the general scenario of electricity wastage. The case study focuses on Academic Building Academic Building 2 in UTP has revealed that the campus is over consuming electricity, especially on lighting. The prototype using PIR motion sensor and light intensity sensor is able to reduce a total of 69.68% of current electricity consumption on lighting in Academic Building 2. This estimation is based on facts, studies and previous data of the building. It is believed that, the education kit is able to help the younger generations to learn to save electricity, thus create a less pollutions and better environment for all.

5.2 Recommendation

In order to achieve accuracy in the study, it is recommended that more case studies should be done, either inside or outside the campus. In fact, the campus is big. Other areas such as students' hostel and Information Resource Canter are also not using green lighting system. More studies have to be done to reveal the pattern of energy spending, so that corrective measures can be taken as early as possible. Besides, a more complete education kit, especially on the appearance of the prototype should also be further improved. Currently, it is built on a breadboard as an experiment set for the users to test, it would be more appealing if it is embedded and enclosed. Apart from that, research should also be done on creating more green lighting system, such as to combine more sensors to further improve saving. Further, green lighting system can also used to combine with other computerized system, such as security system and attendance system to further improve energy-saving.

REFERENCES

[1] P. Robinson, D. Meyers, N. Trilisky and J. Santinelli. (September 15, 2008) *Smart Home: RFID Access Control and Automated Lighting System.*

[2] A.A.Nippun Kumaar, Kiran.G. and Sudarshan TSB. (December 2010) *Intelligent Lighting System Using Wireless Sensor Networks*. International Journal of Ad hoc, Sensor & Ubiquitous Computing (IJASUC) Vol.1, No.4, December 2010.

[3] R. Yozell-Epstein. (2003): *Economic, Energy and User Needs Analysis of Intelligent Lighting Systems*. UC Berkeley.

[4] M. Miki, T.Hiroyasu and K. Imazato. (2004): *Proposal for an Intelligent Lighting System, and Verification of Control Method Effectiveness*. Conference on Cybernetics and Intelligent Systems Singapore, 1-3 December, 2004.

[5] V.Singhvi, A. Krause, C. Guestrin, J.H. Garrett Jr. and H.S. Matthews. *Intelligent Light Control using Sensor Networks*.

[6] Suraj Raj. (July 21, 2008): *Green computing as a way to reduce IT operational costs*. biz.thestar.com.my [Cited: June 23, 2012.] http://biz.thestar.com.my/news/story.asp?file=/2008/7/21/business/21400890&sec=business

[7] D. Du Bois. (June 18, 2007): *What Is Green IT?* energypriorities.com. [Cited: June 23, 2012.] http://energypriorities.com/entries/2007/06/what_is_green_it_buildings.php

[8] D. Tebbutt, M. Atherton and T. Lock. (2009): *Greening Your Organisation*. HP Green IT for Dummies Special Edition.

[9] M.F. Khamidi, A.S.Khalid, R. Rahardjati, & A. Idrus. (2010, October 4): *Universiti Teknologi PETRONAS Energy Retrofitting: Turning Challenges into Opportunities*. Retrieved from: http://eprints.utp.edu.my

[10] M. Z. Kandar, M. S. Sulaiman, R. R. Yong, D. R. Ossen, A. M. Abdullah, Y. W. Lim & M. Nikpour. (2011): *Investigating Daylight Quality In Malaysian Government Office Buildings Through Daylight Factor and Surface Luminance.* World Academy of Science, Engineering and Technology 59 2011.

[11] T. L. Chen. (January 4 2012): GBI - FMM Workshop

[12] Ar V. K. Leong. (April 26, 2010): *Green Building Index, The launch of NREB: NEW LIFE FOR OLD, Plugging the leaks in existing buildings.* Malaysia Green Building Confederation.

[13] L. Halonen, E. Tetri & P. Bhusal. *Chapter 6 : Lighting Control Systems*. Annex 45 Guidebook on Energy Efficient Electric Lighting for Buildings. Retrived from : http://lightinglab.fi/IEAAnnex45/

[14] A.D. Galasiu, G.R. Newsham, C. Suvagau & D.M. Sander. (July 1, 2007): *Energy Saving Lighting Control Systems for Open-plan Offices: A Field Study*. Leukos, v.4, no. 1, July 2007, pp. 7-29. National Research Council Canada.

[15] O.T. Masoso & L.J. Grobler. (February 2010): *The Dark Side of Occupants' Behaviour on Building Energy Use.* Energy and Buildings, Volume 42, Issue 2, February 2020, pp. 173-177.

[16] D.J. Cook, M. Youngblood, E.O. Heierman, III, K. Gopalratnam, S. Rao, A. Litvin & F.Khawaja. (2003): *MavHome: An Agent-Based Smart Home*. Department of Computer Science Engineering, University of Texas at Arlington. Proceedings of the First IEEE International Conference on Pervasive Computing and Communications (PerCom'03).

[17] Malaysian Standard (2007): *Code of Practice on Energy Efficiency and Use of Renewable Energy for Non-residential Buildings.* Department of Standards Malaysia.

[18] H. Kara (April 2007): *On Site Review Report.* University of Technology PETRONAS.

[19] *Educational kits & resources*. (2010). Retrieved from : http://www.horizonfuelcell.com/education_kits.htm

[20] *Renewable Energy Educational Kits and Toys.* (2012). Retrieved from : http://store.sundancesolar.com/soledkitandm.html

[21] *Sustainable Earth Lab.* (2012) Retrieved from : http://www.discoverthis.com/sustainable-earth-lab.html

[22] P.Schiller (November/December 2000): *Early brain development research review and update.* Brain Development, Exchange Magazine.

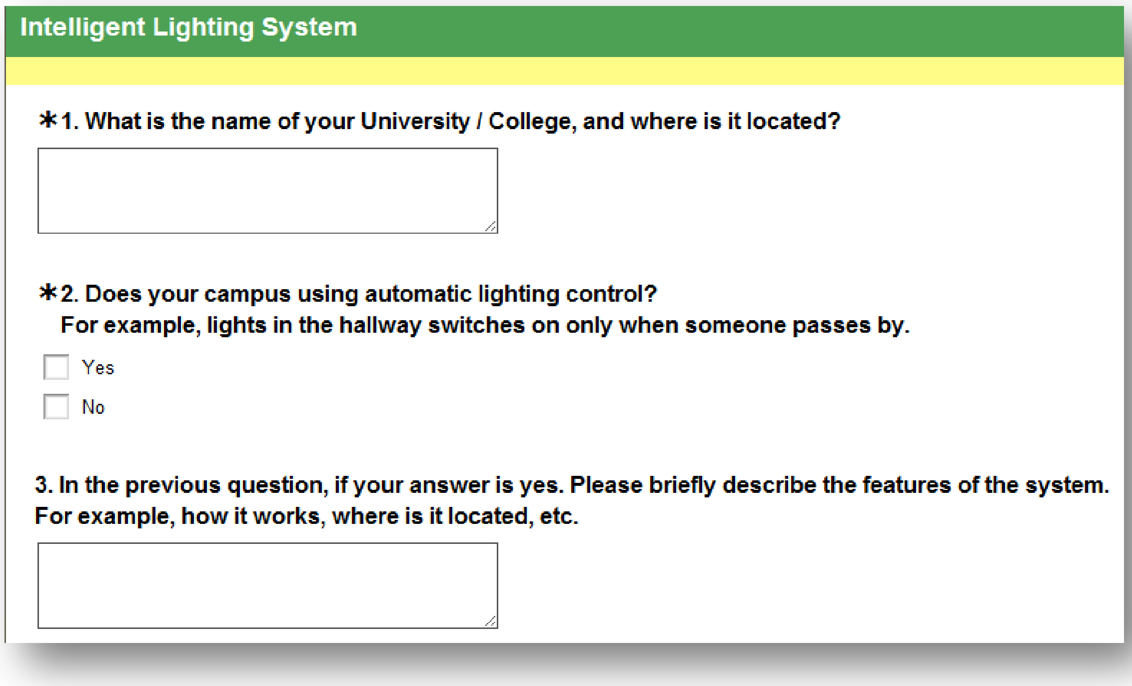
[23] M.L. Crawford (October 2001): *Teaching Contextually.* Research, Rationale, and Techniques for Improving Student Motivation and Achievement in Mathematics and Science.

[24] S.E. Cooperstein & E.Kocevar-Weidinger (2004): *Beyond active learning: a constructivist approach.* Reference Services Review, Volume 21, Number 2, 2004, pp. 141-148, Emerald Group Publishing Llimited.

APPENDICES

Appendix A: Data from short survey regarding opinion of automatic lighting system towards Malaysian students in their respective universities.

1. Semi-structured survey



Intelligent Lighting System

*1. What is the name of your University / College, and where is it located?

*2. Does your campus using automatic lighting control?
For example, lights in the hallway switches on only when someone passes by.

- [ ] Yes
- [ ] No

3. In the previous question, if your answer is yes. Please briefly describe the features of the system.
For example, how it works, where is it located, etc.

Figure 1 : Questionnaire.

2. Results for question 2

2. Does your campus using automatic lighting control? For example, lights in the hallway switches on only when someone passes by.

Create Chart Download

	Response Percent	Response Count
Yes	25.0%	4
No	**75.0%**	**12**
	answered question	**16**
	skipped question	**0**

Figure 2 : Results for question 2.

Results show that only 25 percent out of 16 students found similar energy-saving system in their respective universities. They are all Malaysian and currently pursuing their studies in their universities respectively, mostly local.

3. Results for question 3

Below shows the responds from local students in their respective universities which has similar energy management system.

a) Hochschule Ulm, Ulm, Germany

Respond : 1. In Washrooms 2. Automated window blinds for the whole Institut (sunlight management)

b) NTU/ Singapore

Respond : It works when senses people walking in through the door. Normally located in toilet.

c) University Sains Malaysia, Penang, Malaysia.

Respond : At Library, lights in certain area(the area where less people will pass by) switches on only when someone passes by.

d) University of Wisconsin Madison. US

Respond : it is most probably based on a movement sensor. whenever it senses movement, it triggers the switch to turn on the light. They are mostly located at the ceiling where they can overlook the entire space and track any possible movements.

Appendix B: Tabulated raw data given by Ir Mohd Fatimie Irzaq B Khamis , Senior Executive, Property Management & Maintenance UTP, showing electricity consumption in UTP monthly since 2006.

Month/Year	2006	2007	2008	2009	2010	2011	2012
1	1,633,426	1,933,773	2,101,350	2,209,102	2,213,420	2,145,585	2,350,327
2	1,952,618	2,073,388	2,334,597	2,381,012	2,316,148	2,143,764	2,253,562
3	2,307,943	2,453,958	2,361,829	2,555,906	2,816,429	2,579,341	2,578,884
4	2,255,537	2,456,586	2,635,636	2,698,579	2,743,659	2,540,492	2,563,738
5	2,244,271	2,450,288	2,552,007	2,524,014	2,661,333	2,573,499	2,581,017
6	1,804,493	1,806,823	1,895,182	2,132,466	2,265,943	2,588,224	
7	2,002,396	2,182,060	2,269,720	2,462,270	2,330,057	2,621,303	
8	2,448,774	2,675,982	2,701,620	2,499,930	2,579,886	2,460,283	
9	2,175,682	2,425,968	2,412,634	2,201,984	1,886,807	2,256,704	
10	2,037,498	2,275,808	2,410,778	2,659,222	2,601,195	2,328,173	
11	2,347,860	2,485,915	2,519,581	2,406,188	2,429,648	2,239,001	
12	1,726,801	1,816,425	1,964,736	2,149,744	2,036,547	2,385,762	
Total	**24,937,299**	**27,036,974**	**28,159,670**	**28,880,417**	**28,881,072**	**28,862,131**	**12,327,528**
20%	4987459.8	5407394.8	5631934	5776083.4	5776214.4	5772426.2	2465505.6
RM0.30/kWh	1496237.94	1622218.44	1689580.2	1732825.02	1732864.32	1731727.86	739651.68

Table 1 : Monthly Electricity Consumption in UTP.

Appendix C: Technical Paper

Intelligent Lighting System

An Education Kit to Increase The Awareness of Energy-Saving for Primary School Children.

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***Abstract*—High energy consumption per capita in the country has shown a significant issue pertaining to the overconsumption of electricity. Issue of high consumption of electricity is also occurring in the university. In order to solve this issue, education is necessary to educate the public about the importance of energy-saving. Thus, an education kit consists of an educational website, a lighting device and a case study is introduced with an objective to educate the primary school students about the importance of energy-saving. The lighting device developed in this paper is used to estimate the amount of energy saved in the Academic Building 2, UTP, in order to show how technology can be used to improve the environment. The scope of study covers Academic Building 2, regarding its electricity spent on lighting. The methodology used to develop the education kit is Rapid Application Development (RAD). Results show by using sensors, electricity in Academic Building 2 is reduced by approximately 36.58%.**

***Keywords*—Education Kit; Energy-Saving; Overconsumption of Electricity.**

I. INTRODUCTION

A. Background of Study

The electricity consumption is getting higher and higher in the country. This can be proven by the increase of electricity consumption per capita from 2,468.48 kWh in year 2001 to 3,265.04 kWh in year 2011. This leap is believed to be caused by several factors. The main factors are the lack of awareness of the importance of energy-saving, and over dependent on cooling and lighting system especially in household and commercial buildings. This scenario is obvious in UTP too, where students and staffs do not switch off light once they leave the classrooms, thus energy is wasted. Besides, it pollutes the environment, since non-renewable resources are used to generate electricity.

In order to solve this issue, education is necessary. However, there is a lack of such education tool in the market to achieve this purpose. Thus, an education kit with an educational website, a lighting device and a case study is developed and introduced in this paper.

An education kit can be defined as a package of tools and materials such as pens, pencils, textbooks, disk, dictionary, notebook and computer that are aimed to enhance and facilitate training, teaching or learning processes. Example of education kit in the market is PicoScope Education Kit for students and teachers to perform a variety of experiments. Other example is the Australians at War education kit that contains televisions series about the effects of war on the lives on of Australians for primary and secondary schools.

Green IT or green technology refers to the initiatives to use and design information technology and communication to reduce the negative impacts caused by human activities towards the environment. The lighting device included in the education kit is a miniature prototype that represents the real lighting system in the reality. It is a type of green technology that improves the environment by reducing electricity usage. It is made up of a few main components including the Passive Infrared (PIR) motion sensor and a light intensity sensor. The purpose of having this prototype is to show how technology can be used to improve the quality of the environment by reducing unnecessary electricity consumed. It is also aimed to act as a hands-on material for the primary school students to play around with during their learning process.

The case study is done based on the context in Academic Building 2. It is focused on the electricity consumption on lighting system in the block. The purpose of the case study is to act as a sample to represent the situation for other buildings in the country in general. The study is done to estimate the amount of energy reduced by using the lighting device as proposed. The findings of the case study are included in the education website which acts as the source of reading material for the target user of the education kit. The main purpose of the website is to store information, such as videos on how the prototype works.

B. Problem Statement

High demand of electricity in the country generates a huge quantity of greenhouse gases to the environment. These gases increase the temperature in the atmosphere and causes global warming which in turns lead to the occurrence of disasters such as flash floods. This issue is mainly due to the lack of awareness of the public towards the importance of energy saving, especially on lighting consumption. In order to resolve this issue, education is important, particularly to begin earlier from the younger generations. However, there is a lack of a complete set of tools to help in solving this problem.

In UTP, there is a centralized control system in the academic blocks in the campus, where all the lights and air conditionals are centralized and manipulated by main control. However, the lights are being turn on and off irregularly without concerning the occupancy and the daylight intensity inside the lecture rooms, especially classrooms which are accessible by students. This situation caused so much waste of electricity, and is similar to the general scenario in the country, whereby people are unaware of the importance of energy-saving,

The significance of having an education kit is to solve the issue of overconsumption of electricity from the root cause, which is the user themselves. The target users of the education kit are primary school children from age 7 to 12. It is easier to educate young kids since their minds and behavior are more readily to be shaped. It will be more effective to use a lighting device as a prototype to provide hands-on experience for the children to learn, and the videos in the websites to listen to, rather than plain text book which is not appealing to the users. This education kit can help teachers to transfer scientific knowledge to the primary school students in an entertaining and more attractive way, at the same time, promote the use of green technology initiative to reduce energy consumption to the younger generations.

C. Objective

To develop an education kit that consists of an education website, a lighting device and a case study, to increase the awareness of primary school children about the importance of energy-saving.

Sub-objectives:

(1) To design and develop a lighting system using a PIR sensor module and a light intensity sensor.

(2) To build an educational website to explain about the lighting system, the findings of the case study and the importance of energy-saving to the primary school children.

D. Scope of Study

Location of case study is the Academic Building 2 located whitn the campus, Universiti Teknologi PETRONAS (UTP), where specifically focus on electricity consumption on lighting in classrooms or lecture rooms in the building.

E. Relevancy of the Project

The project is relevant because nowadays, primary students are exposed to technology especially Internet. Besides, there is a lack of such education kit in the market. Furthermore, deteriorating environment condition shows there is a need of such product in the market to educate young children about the important of preserving the environment by using less energy.

F. Feasibility of the Project

The project is feasible to be done. It is completed within time frame, which is 8 months and within budget, RM500, with all the criteria met.

II. LITERATURE REVIEW

A. Education Kits for Green Technology

Education kits in the market have been studied to find out if the similar education kit exists. Education kits for green technology mostly focus on educating the user, usually children about the importance of using renewable energy. Education kit with sensors as proposed in this paper is not found in the market.

B. *Importance of Hands-on Activities in Quality Education*

P.Schiller (2010) says that sense of touch helps children to learn better by understanding abstract ideas concretely. M.L Crawford (2001) stated that students whose teachers conduct hands-on learning in class outperform their peers in math and science. S.E. Cooperstein et al (2004) mentioned that experiences are important in generating knowledge that can last long in human brain.

C. Field Study on Electricity Consumption

M.F. Khamidi et al (2007) conclude that Universiti Teknologi PETRONAS is consuming high quantity of energy for its lighting and cooling system. This paper focuses on finding the root cause of high energy consumption. One of the root cause is inefficient lighting system that in turns generate heat that requires further cooling by the cooling system. A.D. Galasiu et al have done a study on how occupancy sensors save energy in open-plan office area. Result shows a substantial reduce in electricity used after fixing occupancy sensor.

D. Smart-Home Using Sensors to Control Devices at Home

Smart-home is a concept of controlling devices automatically to provide maximum conform and convenience to the users at home, using a range of sensors. Robinson P. et at (2008) and D. J. Cook et al show how this idea can be used in customizing lighting controls for individuals and to maximize user comfort, increase productivity and minimize operational cost.

E. *Human Behavior as a Challenge in Energy-Saving*

The human behavior is the main cause of the overuse of electricity. O.T. Masoso et al have found that human behavior is the root cause of the high energy consumption in a building. The study shows many reasons causing the waste of electricity, which includes air conditions left overnight and laboratory equipment are left running when it is not in use.

F. Daylight Harvesting and Occupancy Sensors in Improving Lighting Efficiency

Potential of daylight harvesting and the use of occupancy sensor are studied by Y.Lin et al (2011), V.Singhvi et al (2005), M.Miki et al (2004), Yozell-Epstein (2003), A.A. Nippun Kumaar (2010), M.Z. Kandar et al (2011). Results of all studies show a reduce of electricity consumed after installing sensors in targeted area respectively.

III. METHODOLOGY

The methodology used in developing the education kit is Rapid Application Development. The method used is prototyping.

A. Information and Data Gathering

Data is gathered by several methods:

(1) Interviews with Ir Mohd Fatimie Irzap B. Khamis, Senior Executive of Property Management and Maintenance Department in UTP, in order to find out the real quantity of electricity consumed in UTP Buildings especially on lighting consumption in Academic Building 2.

(2) Field study by calculating number of light bulbs and number of Watts used by each of the light bulb, in order to find out the total energy used of those light bulbs in an hour.

(3) UTP official website is visited to get the schedules of all classrooms in Academic Building 2, in order to find out the real hours whereby the lights are required to be switch on.

B. Design Architecture

The education website is built using online free hosting website, wix html. The main function of the website is to act as a manual or source of reading material for the students to learn about the education kit. It consists of a home page that writes about what students can do in their daily life in order to preserve the environment and other related topics. Besides, it consists of a page that describes how the lighting device works by showing videos and easy-to-understand description. Apart from that, it contains a page to show the findings of the case study.

The design of the lighting device is shown in the figure below.

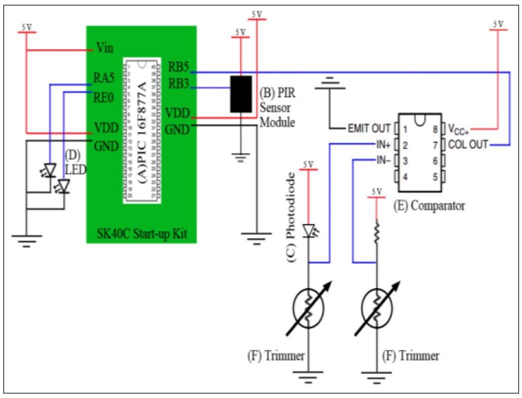

Figure 1: Circuit of the lighting device prototype.

The figure above shows the design architecture of the lighting device prototype. The major component used in the prototype is PIR sensor module that detects motions by detecting the sudden change of temperature in the surrounding. Another main component used in the circuit is the photodiode. It is a light intensity sensor that aims to detect brightness and send a result to the comparator. The comparator will compare the voltage value given by the photodiode with a threshold preset within the comparator. These components will send their respective outputs to the microcontroller to process. The program in the microcontroller is written in C and C++. The LED will light up if the PIR motion sensor detects a motion and the light intensity sensor detects a low brightness in the surrounding.

C. Prototyping

The lighting device together with the education website is built and enhance regularly, where the processes of analysis, design and implementation are repeated, until a satisfied and fully workable education kit is produced.

IV. RESULT AND DISCUSSION

A. Website

The link of the website is http://venicelegolas.wix.com/green-campus. Figure below shows the home page of the website. It displays slides which explaining about what students can do to preserve the environment in their daily life.

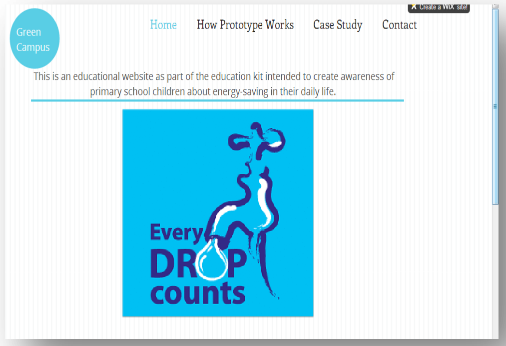

Figure 2: Home page of the education website.

Figure below shows the second page of the website. This page consists of introductions of major components, videos and description about how the prototype works.

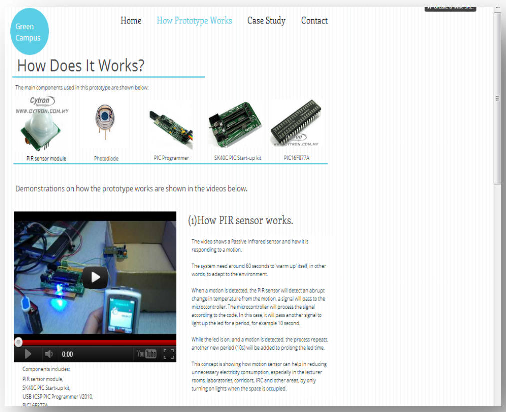

Figure 3: Webpage explaining about the lighting device.

Figure below displays the webpage in the website which shows the findings of the case study. The case study focuses on the electricity consumption of lighting in Academic Building 2, for one month. It includes slides showing the introduction, problem statement, objectives, methodology until the conclusion.

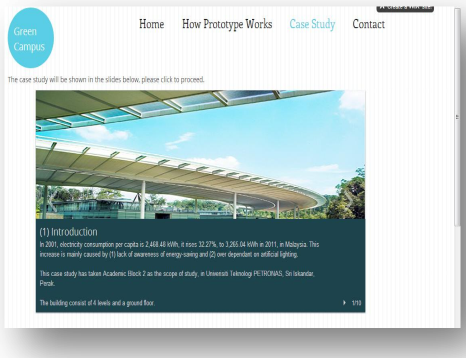

Figure 4: Case study page.

The website uses a lot of pictures along with short explanations. It has a column to post comments for users and also uses videos to convey message, thus making it more interactive.

B. *UTP Electricity Consumption*

The bar chart below shows the annual total electricity consumption in UTP from January year 2010 until May 2012. The y axis shows the electricity consumption in kWh. The x axis shows the months within the years.

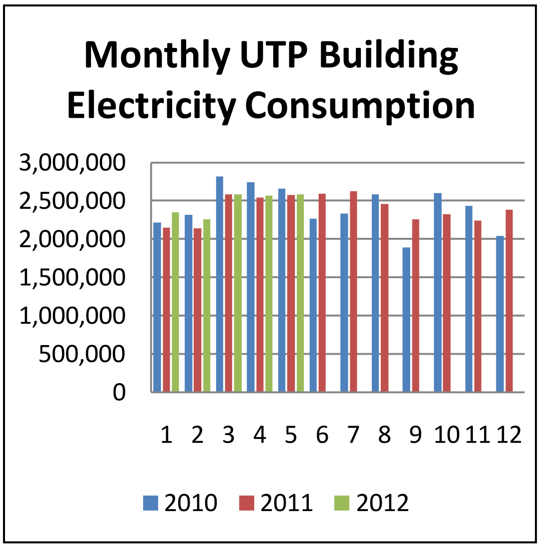

Figure 5: Monthly UTP Building Electricity Consumption.

Table below summarized the total electricity consumption in yearly basis.

Year	Table Energy Consumption (kWh)
2010	28,881,072
2011	28,862,131
2012 (Until May)	12,327,528

Table 1: Annual total electricity consumption in UTP.

In order to check if UTP is consuming electricity wisely, the Green Building Index (GBI) is used. GBI is a green rating system introduced by the Pertubuhan Arkitek Malaysia (PAM) to evaluate the performance of a building across a broad range of environmental considerations. The environmental consideration focusing is the energy efficiency in this study. Below is the formula used, Building Energy Index (BEI).

$$Building\ Energy\ Index\ (BEI) = \frac{Total\ Energy\ Used}{Total\ Area} \quad (1)$$

UTP Building Energy Index in year 2011 is 311 kWh/m^2 . However, the average BEI of Malaysia buildings is range from 200 to 250 kWh/m^2, thus, this study concludes that UTP is over consuming electricity, which proves the problem statement to be true.

C. *Analysis of Electricity Consumption of Lighting in Block 2*

The scope of study is classrooms in academic Block 2, from ground floor to second floor. 3rd floor is omitted because it consists of offices for lecturers. The rooms related to the study are Application Laboratories, Data Communication Laboratory, Multimedia Laboratories, Seminar Room, and Discussion Room. These are the rooms used for teaching and learning purpose and typically, most electricity is spent on these rooms. The number of light bulbs and energy used per bulb are recorded for these floors. Results show that approximately 724.32 kWh of electricity is consumed for an hour if all light bulbs from ground to second floor are turn on.

In order to achieve accuracy, real electricity consumption of previous year is used. It is assumed that the total electricity consumed per month this year is similar to the average electricity consumed per month last year.

Total consumption per month
= 393,452 kWh / 12 months
= 32,787.67 x 20% on lighting
= 6,557.53 kWh per month (2)

Focus of the study does not include 3^{rd} floor, thus it is omitted by assuming that 25% is used.

Total consumption
= 6,557.53/4 = 1,639.38 kWh per floor
= 1,639.38 x 3
= 4,918.15 kWh for ground,
first and second floor (3)

Among the total energy used, 30% is allocated as consumption for other non-classrooms, such as technician rooms, toilets, corridors and utilities rooms. Thus, the remaining energy is spent in classrooms.

$$4{,}918.15 \times 70\% = 3{,}442.71 \text{ kWh} \quad (4)$$

If the result is divided by total energy used per hour, the number of hours where the lights in classrooms are switch on can be found.

$$\frac{3{,}442.71 \text{ kWh per month}}{724.32 \text{ kWh per hour}} = 4.75 \text{ hours} \quad (5)$$

The schedules of classrooms in Academic Building 2 are referred and the number of light bulbs and its energy used are recorded earlier in order to find out the number of hours where the lights in certain classrooms have to be switched on. 10% Of this consumption is added for special events, such as extra classes and bookings by lecturers which are not included in the time table.

Results show that the estimated lighting used per month in classrooms is 3,400.52 kWh, while the real required consumption per month is only 1,391.0 kWh. Thus, this study concludes that, lights are switched on even it is not in used. With a PIR motion sensor alone, 59.57% of this energy can be reduced, whereby it eliminates the lights from turning on when the classrooms are not occupied.

D. Light Intensity in Academic Building 2

The study on the brightness in the lecture room is carried out in Data Communication Laboratory, in Academic Building 2. The light intensity of the classroom is measured for 4 continuous days, from 26 October 2012, to 29 October 2012. The light meter is located 3 meters from the light source. Figure below shows the results of the brightness in the laboratory, measured in Lux.

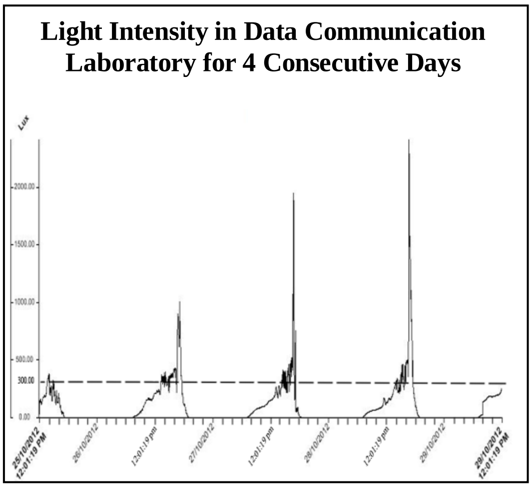

Figure 6: Light Intensity in a Classroom in Academic Building 2.

According to the results, the highest value measured is 2,414 Lux while the lowest is 0 Lux, and the average is 98.398 Lux. The highest reading taken on day 3, 28 October 2012, 4:40:19 pm, while lowest reading happens after the sun goes down. The dotted line represents hours that achieve the brightness of 300 Lux. 300 Lux is the standard brightness for classroom and library according to the Malaysian Standard (2007). Thus, this study shows that there is a potential of daylight harvesting in classrooms in the Academic Building. The following pie chart shows the summarized estimations of energy spent on lighting in the Academic Building 2.

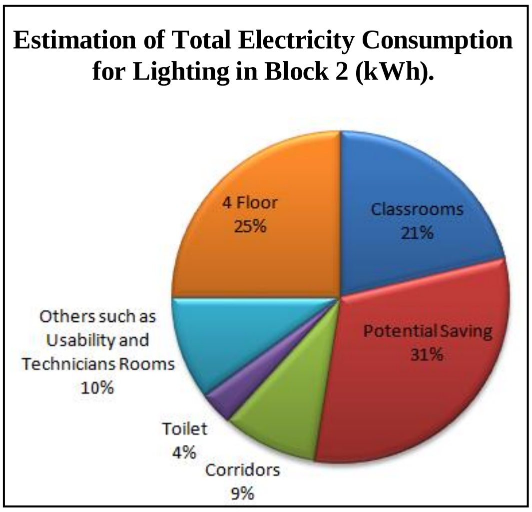

Figure 7: Estimation of Total Electricity Consumption for Lighting in Block 2 for one month.

By using a light intensity sensor, it can help to reduce the required hours to switch on the light, especially during the afternoon class hours, thus another 5.3% of saving can be achieved. This study concludes that, PIR motion sensor and light intensity sensor can help to reduce electricity consumed in the building by approximately 36.58%, which in turns proves that the use of technology can improve the quality of environment.

V. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusion

High energy consumption generates a huge amount of harmful greenhouse gases to the environment. The root cause of this problem is the ignorant human behavior of their responsibilities towards the environment. The education kit presented in this study aims to contribute to the environment by increasing the awareness of primary school children about the importance of energy-saving. The education kit consists of an educational website, a prototype and a case study. The case study reveals that by using sensors, electricity consumption can be reduced by approximately 36.58% in Academic Building 2. The study shows that education and technology are necessary in order to improve the quality of the environment.

B. *Recommendation*

More case studies should be done to find out a more accurate energy consumption pattern in the campus. Besides, study can also be done outside the campus to gather different data. Apart from that, a more presentable education kit can be produced, for instance, to make it embedded rather than to expose all the components.

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REFERENCES

[1] P.Schiller (November/December 2000): *Early brain development research review and update.* Brain Development, Exchange Magazine.

[2] M.L. Crawford (October 2001): *Teaching Contextually.* Research, Rationale, and Techniques for Improving Student Motivation and Achievement in Mathematics and Science.

[3] S.E. Cooperstein & E.Kocevar-Weidinger (2004): *Beyond active learning: a constructivist approach.* Reference Services Review, Volume 21, Number 2, 2004, pp. 141-148, Emerald Group Publishing Llimited.

[4] M.F. Khamidi, A.S.Khalid, R. Rahardjati, & A. Idrus. (2010, October 4): *Universiti Teknologi PETRONAS Energy Retrofitting: Turning Challenges into Opportunities.* Retrieved from: http://eprints.utp.edu.my

[5] A.D. Galasiu, G.R. Newsham, C. Suvagau & D.M. Sander. (July 1, 2007): *Energy Saving Lighting Control Systems for Open-plan Offices: A Field Study*. Leukos, v.4, no. 1, July 2007, pp. 7-29. National Research Council Canada.

[6] P. Robinson, D. Meyers, N. Trilisky and J. Santinelli. (September 15, 2008) *Smart Home: RFID Access Control and Automated Lighting System.*

[7] D.J. Cook, M. Youngblood, E.O. Heierman, III, K. Gopalratnam, S. Rao, A. Litvin & F.Khawaja. (2003): *MavHome: An Agent-Based Smart Home*. Department of Computer Science Engineering, University of Texas at Arlington. Proceedings of the First IEEE International Conference on Pervasive Computing and Communications (PerCom'03).

[8] O.T. Masoso & L.J. Grobler. (February 2010): *The Dark Side of Occupants' Behaviour on Building Energy Use*. Energy and Buildings, Volume 42, Issue 2, February 2020, pp. 173-177.

[9] Y. Lin, W. Cheng, C. Wu, Y. Sun. (2011).: *An Intelligent Lighting Control System Based on Ergonomic Research. Consumer Electronics, Communications and Networks (CECNet), 2011 International Conference , 16-18 April 2011.*

[10] V.Singhvi, A. Krause, C. Guestrin, J.H. Garrett Jr. and H.S. Matthews. *Intelligent Light Control using Sensor Networks*.

[11] M. Miki, T.Hiroyasu and K. Imazato. (2004): *Proposal for an Intelligent Lighting System, and Verification of Control Method Effectiveness*. Conference on Cybernetics and Intelligent Systems Singapore, 1-3 December, 2004.

[12] R. Yozell-Epstein. (2003): *Economic, Energy and User Needs Analysis of Intelligent Lighting Systems*. UC Berkeley.

[13] A.A.Nippun Kumaar, Kiran.G. and Sudarshan TSB. (December 2010) *Intelligent Lighting System Using Wireless Sensor Networks.* International Journal of Ad hoc, Sensor & Ubiquitous Computing (IJASUC) Vol.1, No.4, December 2010.

[14] M. Z. Kandar, M. S. Sulaiman, R. R. Yong, D. R. Ossen, A. M. Abdullah, Y. W. Lim & M. Nikpour. (2011): *Investigating Daylight Quality In Malaysian Government Office Buildings Through Daylight Factor and Surface Luminance.* World Academy of Science, Engineering and Technology 59 2011.

[15] Malaysian Stan dard (2007): *Code of Practice on Energy Efficiency and Use of Renewable Energy for Non-residential Buildings.* Department of Standards Malaysia.