POTENTIAL INNOVATION OF ENERGY EFFICIENCY BUILDING IN GOVERNMENT COMMUNITY COLLEGE

AHMAD FIKRI BIN MOHAMED OMAR

UNIVERSITI TEKNOLOGI MALAYSIA

PSZ 19:16 (Pind. 1/07)

UNIVERSITI TEKNOLOGI MALAYSIA

DECLARATION OF CAPSTONE PROJECT PAPER AND COPYRIGHT

Author's full name : **AHMAD FIKRI BIN MOHAMED OMAR**

Date of birth : **22 OCTOBER 1977**

Title : **POTENTIAL INNOVATION OF ENERGY EFFICIENCY BUILDING IN GOVERNMENT COMMUNITY COLLEGE**

Academic Session: **SEMESTER I SESSION 2013/2014**

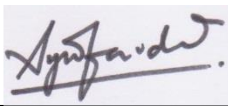
I declare that this thesis is classified as :

☐	**CONFIDENTIAL**	(Contains confidential information under the Official Secret Act 1972)*
☐	**RESTRICTED**	(Contains restricted information as specified by the organization where research was done)*
☐	**OPEN ACCESS**	I agree that my thesis to be published as online open access (full text)

I acknowledged that Universiti Teknologi Malaysia reserves the right as follows:

1. The thesis is the property of Universiti Teknologi Malaysia.
2. The Library of Universiti Teknologi Malaysia has the right to make copies for the purpose of research only.
3. The Library has the right to make copies of the thesis for academic exchange.

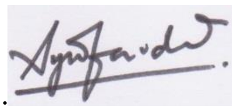
Certified by :



SIGNATURE	**SIGNATURE OF SUPERVISOR**
771022-08-7131	**Dr. Syuhaida Binti Ismail**
(NEW IC NO. /PASSPORT NO.)	**NAME OF SUPERVISOR**
Date : January 2014	Date : January 2014

NOTES : * If the thesis is CONFIDENTAL or RESTRICTED, please attach with the letter from the organization with period and reasons for confidentiality or restriction.

"I hereby declare that I have read this capstone project
and in my opinion this capstone project is sufficient
in terms of scope and quality for the award of the degree
of Master Of Project Management"

Signature : ……………………..........

Name of Supervisor : Dr. Syuhaida Binti Ismail

Date : January 2014

POTENTIAL INNOVATION OF ENERGY EFFICIENCY BUILDING IN GOVERNMENT COMMUNITY COLLEGE

AHMAD FIKRI BIN MOHAMED OMAR

A capstone project report submitted in partial fulfilment
of the requirements for the award of the degree of
Master of Project Management

Faculty of Civil Engineering
Universiti Teknologi Malaysia

JANUARY 2014

I declare that this capstone project report entitled *"Potential Innovation Of Energy Efficiency Building In Government Community College"* is the result of my own work except as cited in the references. The capstone project has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	:	…………………………
Name	:	AHMAD FIKRI BIN MOHAMED OMAR
Date	:	January 2014

ACKNOWLEDGEMENTS

In completing this project, I would like to thanks several peoples namely;

i) Dr. Syuhaida Ismail for being very accommodative and for her insightful knowledge in guiding me to complete this report,

ii) Management and other KKBB staffs for spending their time to discuss with me,

iii) My wife, my kids and my parents for their support, and last but not least

iv) My UTM colleagues for helping me from time to time.

ABSTRACT

The management of Kolej Komuniti Bayan Baru (KKBB) building in Penang lamented that they need to pay high monthly electricity bill when compared to other community colleges of the same floor area. The aim of this study is to propose potential innovative solution(s) to KKBB building towards being an energy efficient building. The study begins with planning phase that is to review articles and journals. Then the data collection and interview was done to better understand the problems. Lastly, the data was analysed and detail proposal together with the payback period will be made. The results will be compared again with the literature review and data. The study has identified two solutions by using innovative products that are readily available in the market. The first solution is changing of water-cooled package air-conditioning system into Variable Refrigerant Flow (VRF) system. The second solution is changing of existing fluorescent lamps into Light Emitting Diode (LED).

ABSTRAK

Pengurusan Kolej Komuniti Bayan Baru (KKBB) bangunan di Pulau Pinang menyatakan mereka perlu membayar bil elektrik bulanan yang tinggi berbanding dengan kolej komuniti lain yang mempunyai ruang lantai yang hampir sama. Tujuan kajian ini adalah untuk mencadangkan penyelesaian yang berdasarkan inovasi terkini untuk bangunan KKBB ke arah menjadi sebuah bangunan yang cekap tenaga. Kajian ini bermula dengan fasa perancangan iaitu untuk mengkaji semula artikel dan jurnal. Kemudian pengumpulan data dan temu bual telah dilakukan untuk lebih memahami masalah bangunan ini. Akhir sekali, data akan dianalisa dan cadangan terperinci termasuk tempoh bayaran balik akan dibuat. Keputusan akan dibandingkan lagi dengan kajian literatur dan data. Kajian ini telah mengenalpasti dua penyelesaian dengan menggunakan produk-produk inovatif yang sedia ada di pasaran. Penyelesaian pertama adalah dengan menggantikan pakej sistem penghawa dingin *water-cooled package* kepada sistem *Variable Refrigerant Flow* (VRF). Penyelesaian kedua adalah dengan menggantikan lampu kalimantang sedia ada dengan lampu Diod Pemancar Cahaya (LED).

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

GBI	-	Green Building Index
KKBB	-	Kolej Komuniti Bayan Baru
VRF	-	Variable Refrigerant Flow
LED	-	Light Emitting Diode
KeTTHA	-	Ministry of Energy, Green Technology and Water, Malaysia
TNB	-	Tenaga Nasional Berhad
EPU	-	Economic Planning Unit

CHAPTER 1

INTRODUCTION

1.1 Introduction

A green building is an environmentally sustainable building, designed, constructed and operated to reduce the overall environmental impacts. Key strategies for achieving a green building include lowering energy consumptions regardless it is via architectural, mechanical, electrical or other approach.

In other words, green building also refers to the structure and operation that is environmentally friendly throughout the life of the building. Hence it requires close coordination between the client, consultants and contractor in all phases of the project (Yan Ji, 2006). Practices of green building complements the classical building design concerns of economy, function, reliability and comfort (US EPA, 2009).

Green buildings will be well designed to save operating expenses as well as provides a healthier environment for people to live and work, using and improving the quality of indoor air, natural daylight, and thermal comfort. Rising energy costs and increased environmental awareness on issues such as global warming, makes energy efficiency and conservation a high priority.

In many ways, the Green Building is really a range of possibilities for most designers and builders in a number of overlapping areas. In practice, the Green Building is really a convergence of a number of similar transactions: solar homes, better well-being, healthy living, environmental friendly, reuse products and energy efficiency.

Green Building usually requires Green Technology as tools, though more expansive. According to Ministry of Energy, Green Technology and Water, Malaysia (*KeTTHA*), Green Technology refers to products, devices, or systems that meet the following criteria. On the other hand it minimizes damage to the environment, has little or no greenhouse gas (GHG) emissions, safe for use and promotes healthy and better environment for all forms of life, conserves the use of energy and natural resources and stimulates the use of renewable resources. (*KeTTHA* 2013)

Seeing as Green Building nowadays has becoming a trend amongst various prominent organizations as a part of its reputation despite as an endeavor towards energy efficiency, Ministry of Education which is the owner of community college has started to look into the idea of Green Building.

1.2 Problem Statement

Community colleges are key to the development of human capital of the local municipalities through the provision of information and skills, such as imprinting the positive values and ethics through education and creation of a lifelong learning environment (LLE). Furthermore, the community colleges serve as an important hub for lifelong learning that offers skills for the local community without limiting students with age or race. Overall there are 84 community colleges throughout Malaysia. One of them is Kolej Komuniti Bayan Baru (KKBB) operates in Bayan Lepas, Penang which its building will be the case study for this capstone project.

Kolej Komuniti Bayan Baru started to operate from their newly renovated building in late 2011. The management of KKBB building in Penang lamented that they need to pay higher electricity bill compared to other community colleges in Malaysia of the same area. They foresee that the bills will spiral upwards when full intake of students will materialize soon and all the equipment will be fully utilized. They believe that by having a proper study, a solution will arise to solve the problems.

Amongst the brainstorming idea in solving this problem is through the implementation of energy efficient building which might have most of the Green Building elements. Therefore, in order to relate Green Building and energy efficient building in general with KKBB towards its aim of reducing electricity bills, a study is essential to be undertaken in looking deeply into the aforementioned areas of study.

1.3 Aim and Objectives

The aim of this study is to propose innovative solutions (new product/ equipment/ system) to KKBB building towards an energy efficient building. To achieve the aim, there were several objectives that have been decided in this study which are:

a. To identify the energy consumption of KKBB

b. To investigate the requirement of energy efficient building in Malaysia

c. To examine the expected cost saving of KKBB after using the proposed innovative solution(s)

1.4 Research Questions

The research questions mainly comprise of the following based on subjects below:

a. is the current energy consumption of KKBB?

b. What is the requirement of energy efficient building in Malaysia?

c. How much can KKBB save in terms of cost after using the proposed innovative solutions by this study?

1.5 Scope of Study

For the purpose of this study, one Community College that was newly renovated by the Education Ministry is chosen. The building itself was a former clubhouse catering mostly the expatriates in Penang. When the Ministry bought this building, the building was already vacant and in a sorry state. The renovation, undertaken by the technical staffs at the Ministry costs around RM7 million and fully commissioned as community college in August 2011. (Ministry Of Education, 2013)

This study will focus on the innovation of green building. It will use Green Building Index (GBI) as the reference. The solutions however, will not break any law set by Uniform Building By-Law, Energy Commission, Fire and Rescue Department and other related by-law.

1.6 Research Methodology

The first phase of this study is to determine the aim, objectives and scope based on discussion with supervisor and recommendation from the KKBB management. This is further supported by searching and reading literature from various sources such as publications, journals and thesis. The literature review is done in order to support the aim, objectives scope and methodology of the study based on the current standard practice and with existing similar model.

This study starts with identification of research problems statement, which covered aim of the research, objectives and scope of study. The study begins with revision to books, journals and also from reliable website. The exploration in literature review provides in-depth review on area or topic of energy efficient, carbon emission and payback of investment.

Second phase of data collection will utilize interview method with the KKBB staffs. The respective respondents are the building management practitioners including the Maintenance Officer and his team of technicians. After the data collection completes, then data will be analysed in order to get the solutions. Improvement is done if necessary. Finally, the capstone project report is prepared and submitted.

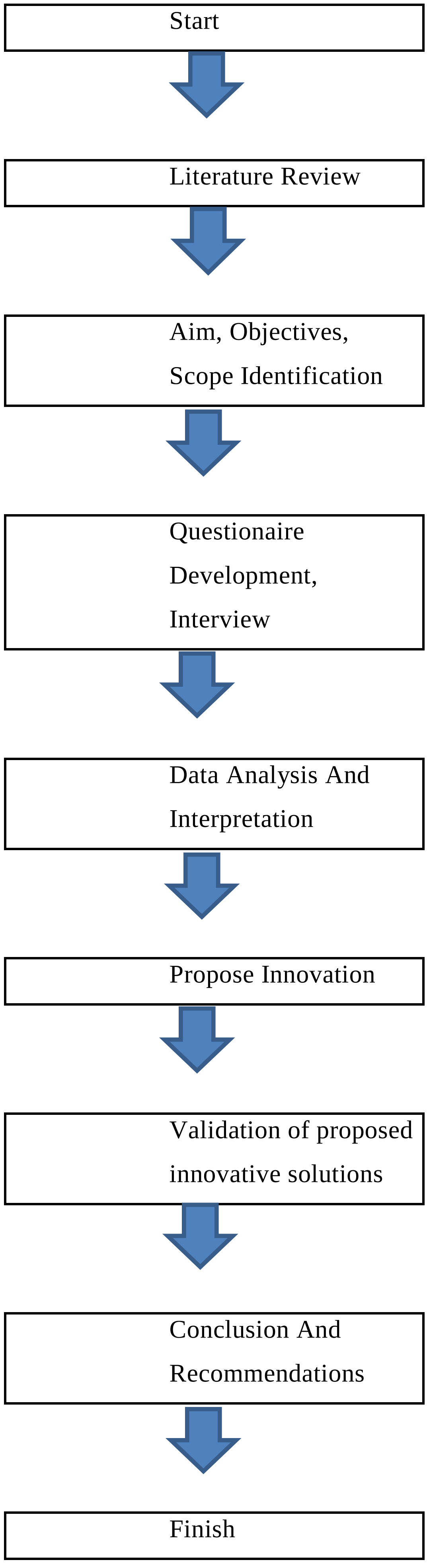


Figure 1.1 The Research Methodology chart

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Although the aim of this study will not be towards achieving Green Building, it is worth mentioning that Innovation and Energy Efficiency are part of the criterias stated in Green Building certification that will mention later in this chapter. This chapter will discuss further on Green Building, the payback period and criteria on energy efficient building.

2.2 Green Building

Green buildings is a buildings that are designed, constructed and operated to boost environmental, economic, health and productivity performance over conventional building (U.S. Green Building Council, 2003).

According to Cassidy (2003), green building is the practice of raising the efficiency with which buildings and their sites use energy, water and materials. In additions green building aims at reducing impacts on human health and the environment through better siting, design, construction, operation, maintenance and demolition. These are the complete building life cycle.

According to the United States Environmental Protection Agency (2009), green building generally refers to a permanent building and using process that is environmentally responsible and energy efficient throughout a building's life-cycle: from the design phase, construction, operation and maintenance, and demolition. Buildings in the US are estimated to be responsible for 39 per cent of the energy used, 71 per cent of the electricity and 12 per cent of the water consumed, as well as for 39 per cent of CO 2 emissions and 65 per cent of waste produced (USGBC, 2009).

Existing research suggests that green buildings can reduce energy and material usage and improve occupant health and performance (USGBC, 2009; Singh, 2010). In other words, a green building is also known as a sustainable or high performance building. The need for building green arose out of the need and desire for more energy efficient and environmentally friendly building practices. However, in Malaysia the demand for such buildings is not that high because higher initial construction cost, thus higher selling price. (Suvarna Ooi, 2010).

Green building brings together a wide range of practices and techniques, and skills necessary to reduce and ultimately eliminate the impacts of buildings on the environment and human health. It often confirms benefit from renewable resources, for example, using the sun's rays through the equipment of active solar and passive solar, and the use of plants and trees through green roofs and gardens rain, and the reduction of rainwater run-off (Figure 2.1) .

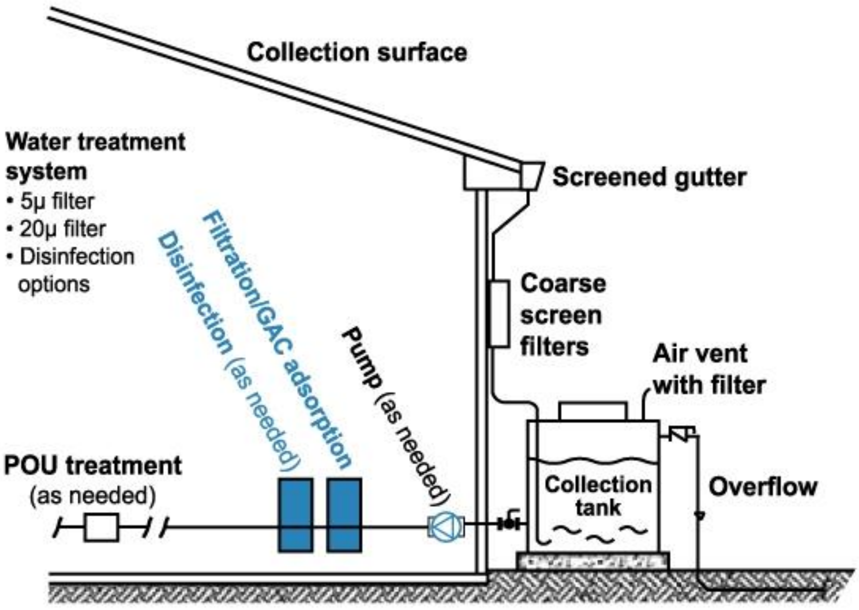


Figure 2.1 Schematic diagram of rain water harvesting system
Source: www.cleanairpurewater.com

It used many other technologies, such as the use of low-impact building materials or using packed gravel or permeable concrete instead of conventional concrete or asphalt to enhance replenishment of groundwater .

While the practices or techniques used in green building are constantly evolving and can vary from one region to another, the basic principles are basically: Siting and Structure Design Efficiency, Energy Efficiency, Water Efficiency, Materials Efficiency, Indoor Environmental Quality Enhancement, Operations and Maintenance Optimization, and Waste and Toxics Reduction.

2.2.1 Siting and Structure Design Efficiency

Intention of sustainable design is to eliminate the negative environmental impact completely through skillful, sensitive design. Beyond eliminating negative environmental impacts, a sustainable design projects must have a dynamic balance between the economy and society, and aims to generate long-term relationships between the user and the object / service, and finally to be dutiful and mindful of the environmental and social differences.

The principle that all directions of progress is running out, and ending with diminishing returns, is evident in the 'S' curve of a typical life cycle of technological product and the useful life of any system. Business management practice is common to read of diminishing returns in any direction from the voltage indication of the dwindling opportunity, and the possibility of accelerating the decline and signal to look for new opportunities elsewhere.

The problem arises when the resource limits of hard to see, so increased investment in response to diminishing returns may seem as profitable as in the Tragedy of the Commons, but it may lead to collapse. Relieve over-stressed resources requires the reduction of pressure on them, and not increase continuously whether or not a more efficient.

The limits of sustainable design are reducing. Entire impacts are beginning to be considered as the growth of goods and services is constantly pushing the efficiency gains. The current approach, which focuses on the efficiency of the delivery of individual goods and services, does not solve this problem.

The basic dilemmas include: the increasing complexity of efficiency improvements, the difficulty of implementing new technologies in societies built around old building, that the physical impacts of delivering goods and services are not localized, but distributed through economies of scale and the use of resources is growing and not stabilizing.

Sustainable architecture is the design of sustainable buildings. Sustainable architecture combine with building components during the construction process to reduce environmental impacts during the production team, as well as the life of the building (heating , electricity use , carpet cleaners , etc.). Working closely with the design team, architects, engineers, and clients at all stages of the project site selection, scheme formation, material selection and procurement for the implementation of the project requires.

2.2.2 Energy Efficiency

Green buildings typically include measures to reduce energy consumption. To reduce operating energy consumption, designers use the details that reduce air leakage through the building envelope (the barrier between conditioned and unconditioned space). They also determine the high-performance windows and extra insulation in walls, ceilings, and floors. Another strategy, passive solar building design, is often implemented in low-energy houses.

Designers adjust the windows and walls and place awnings, porches, and trees shade windows and roofs during the summer while maximizing solar gain in the winter. Furthermore, effective window positioning can provide more natural light and lessen the need for electric lighting during the day. Solar water heating further reduce energy costs.

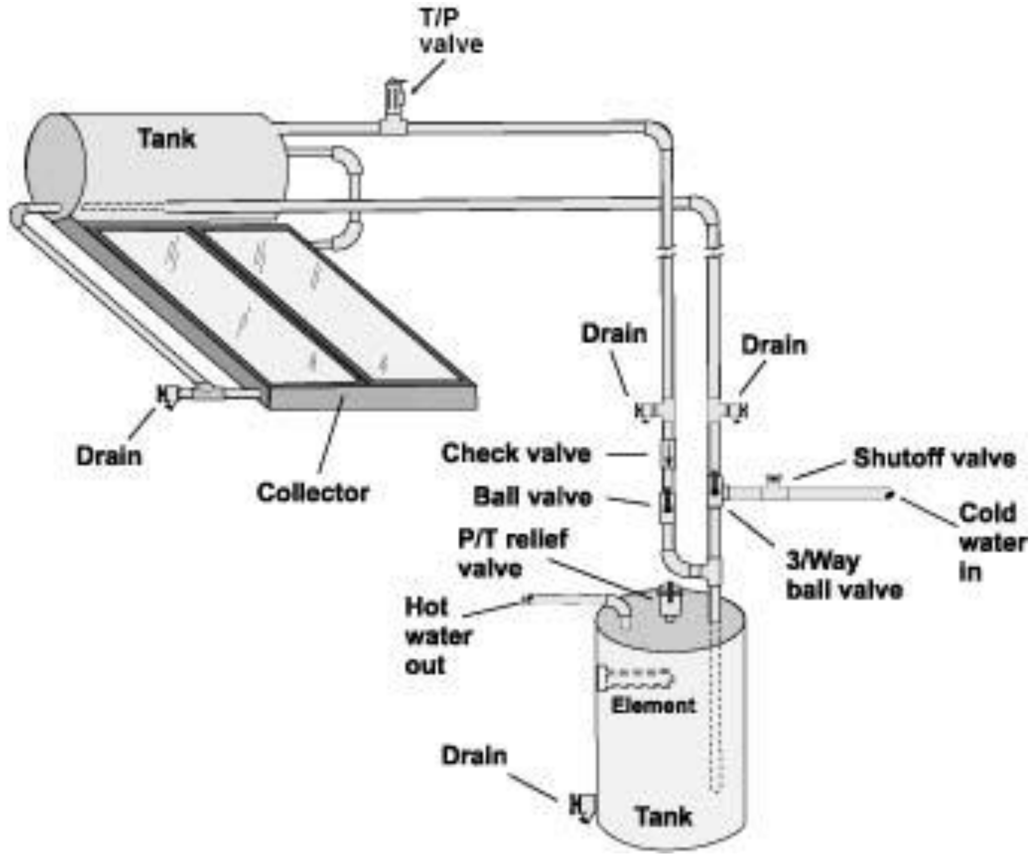


Figure 2.2 Schematic view of solar water heater
Source: www.ucsusa.org

Traditional buildings consume 40% of the total fossil fuel energy in the United States and the European Union and is a major contributor to greenhouse gases. The principle of net zero energy consumption is seen as a way to reduce carbon emissions and reduce dependence on fossil fuels and even zero energy buildings remain uncommon even in developed countries, they are increasingly important and popularity.

Most zero energy buildings use electricity grid for energy storage, but there are independent from the grid. Energy is usually harvested at the site through a combination of energy producing technologies such as solar and wind, while reducing the overall energy consumption of highly efficient HVAC and lighting technology. The goal of zero energy becomes more practical as the cost of alternative energy technologies and the decreasing cost of traditional fossil fuels increase.

Modern developments of zero energy buildings became possible not only through advances in energy and construction technologies and new techniques, but also increased significantly by academic studies, which collect accurate data on the energy performance of traditional and experimental buildings and provide the performance parameters for advanced computer models to predict the effectiveness of the design techniques.

The steps are the most cost-effective to reducing energy consumption of buildings usually occur during the design process. To achieve energy efficiency, zero energy design differs a lot from conventional construction practice. Successful zero energy building designers typically combine time tested passive solar, or artificial condition, the principles of working with asset site.

Zero- energy buildings built with significant energy-saving features. Heating and cooling load reduced by using high-efficiency equipment, added isolation, high efficiency windows, natural ventilation, and techniques - another technique. This feature varies depending on the climate zone in which development occurs.

Many electrical loads can be reduced by choosing efficient appliances and reduce phantom load or standby power. Other techniques to achieve net zero (depending on climate) are earth sheltered building principles, using straw bale wall construction superinsulation, prefabricated building panels and roof elements plus outdoor scenery for seasonal shading.

Zero energy concept of coaching has become their progressive evolution of other forms of low-energy buildings. Among them, the R-2000 Canadian and German passive house standard has become influential in the international benchmark.

Figure 2.3 View of a zero-energy building building in Bangi, Selangor.

2.2.3 Water Efficiency

Reducing water consumption and protecting water quality is the ultimate goal of sustainable development. One important issue of water consumption is that in many areas, the needs of the aquifer provides more than the ability to add your own. As far as feasible, facilities should increase their dependence on water that is collected, used, purified, and reused on site .

Protection and conservation of water throughout the life of the building can be achieved by designing for dual plumbing to recycle the water in the toilet water, or using water to wash the car. Waste water can be reduced by using water conservation fixtures such as ultra - low flush toilets (Figure 2.4) and low flow showerheads.

Figure 2.4 Dual flush water that lessen the water usage

Source: www.rensup.com

New technologies pose several new options for consumers, and features such as a full flush and half flush when using the toilet trying to make a difference in water consumption and waste. Also available in our modern world is a shower head which helps reduce water waste, old shower head is said to use 5-10 gallons per minute. All new equipment available is said to use 2.5 gallons per minute and offer the same water coverage.

2.2.4 Indoor environmental quality enhancement

Indoor Air Quality (IAQ) seeks to reduce volatile organic compounds, or VOCs, and other air filths such as microbial contaminants. Building ventilation systems rely on well-designed (passive/ natural or mechanically powered) to provide adequate ventilation of cleaner air from outdoors or recirculated, filtered air as well as isolated operations from other occupancy.

2.2.5 Operations and maintenance optimization

Whatever may be the sustainable building in its design and construction, it can only remain so if it is run responsibly and properly maintained. Educating the operations and maintenance staffs are part of the planning process and development of the project will help maintain green standards designed at the beginning of the project.

Although the goal of reducing waste can be applied during the design, construction and demolition stages of the life cycle of the building, which is in the O & M phase that green practices such as recycling and enhancing the quality of the air takes place.

2.2.6 Waste Reduction

Green architecture also seeks to reduce waste of energy, water and materials used during construction. During the construction phase, reducing the amount of material going to landfills should be one goal to target. Green design buildings also help to reduce the amount of waste generated by the occupants as well, by providing on-site solutions such as compost bins to reduce matter of going to landfills.

Deconstruction is a method for collecting what is usually considered "waste" and reuse it as a building materials. Extending the useful life of the structure also reduces waste. For example building materials such as wood that use to be made as roof trust can be reused in other future projects.

To reduce the impact on wells or water treatment plants, there are several options. Wastewater from sources such as dishwashing or washing machines, and can be used for irrigation under the surface of the ground, or if the treatment for non- drinking purposes, for example, in the toilets and wash cars.

2.3 Green Building Index (GBI)

Green Building Index (GBI) is Malaysia's green rating tool for buildings and towns, created to promote sustainability in the built-environment and raise awareness of environmental issues. There are six criteria of GBI which are used to rate the 'green' status of a particular building as shown in Table 2.1

Table 2.1 GBI Criteria and Description

NO	CRITERIA	DESCRIPTION
1	Energy Efficiency (EE)	Improve the energy consumption by optimizing the orientation of the building, minimizing solar heat gain through the building envelope, harvesting natural lighting, the use of best practices in building services including use of renewable energy and ensuring the proper testing, commissioning and sustainable regular maintenance.
2	Indoor Environmental Quality (EQ)	To achieve good indoor environmental performance of the indoor air quality, acoustic, visual and thermal comfort. Those involved in the use of low volatile organic compound materials, the application of quality air filtration, proper control of air temperature, movement, and humidity.
3	Sustainable Site Planning & Management (SM)	Selecting suitable sites for the planned access to public transportation, community facilities, open spaces and landscaping. Avoidance and preservation of environmentally sensitive areas through the redevelopment of existing sites and soils. Implementation of the interpreted control, stormwater management and reduce the pressure on existing infrastructure capacity.
4	Materials & Resources (MR)	To promote the use of environmentally friendly materials sourced from sustainable sources and recycling. Implementation of waste management interpreted the storage, collection and reuse of recyclable and mold and waste.
5	Water Efficiency	Rainwater harvesting, water recycling and water-efficient fittings.
6	Innovation (IN)	Innovative design and initiatives that meet the objectives of the GBI.

Source : Greenbuidingindex Sdn Bhd (2013)

Each of the six criterion stated above will contribute marks. The final score will decide the rating of the building. The marks less than fifty(50) will not be certified as Green Building.

Table 2.2 GBI Classification

MARKS	GBI RATING
86+ marks	Platinum
76 to 85 marks	Gold
66 to 75 marks	Silver
50 to 65 marks	Certified

Source : Greenbuidingindex Sdn Bhd (2013)

2.4 Payback Analysis

Although this study is focusing on Energy Efficiency improvement of KKBB, it is essential to discuss the payback analysis because it will determine whether the proposed innovative solution of this study is value for money or vice versa. Hence this section will elaborate more on what payback analysis is all about.

Various investment proposals can be ranked in one of several ways. Use of the payback analysis involves computation of the number of years required to recover the initial investment. The payback method is a popular method of looking of project return especially in the government sector. It tells how long it will take to earn back the money that has been spent on the project.

The formula is:

Cost of Project / Annual Cash Inflow = Payback Period

Payback analysis can also be slightly improved by modifying the approach to include the effects of debt service. For example, if it is found that an initial investment of RM100,000 results in an annual operating and maintenance savings of RM20,000, to conclude that such a proposal has a simple payback of five years is to ignore the present/future value of money factor.

Under the payback method of analysis, projects or purchases with shorter payback periods are considered better than those with longer paybacks. The theory is that projects with shorter paybacks are more liquid in which it allows to recoup the investment sooner, hence the money could be invested elsewhere.

Based on joint research by Rockefeller Foundation and Deutsche Bank Climate Change Advisor on payback estimation done in 2011, it can be seen that most of innovative products evaluated have less than eight years of payback. The details are shown in table 2.3;

Table 2.3 Innovative products and its payback

Innovative products	Payback (yrs.)
Controls	
Controls retrofits and control approaches	3-4
Demand controlled ventilation	2-5
Mechanical	
Variable flow primary/secondary systems with controls, VFDs	2-4
HVAC	
Constant velocity air handlers to variable air volume	2-4
VAV boxes, control set points, box flow minimums	5+
Boiler exchanges from steam to hot water	5-8
High efficiency fully condensing boilers	6-8
High efficiency VFD chiller system	8-12
Lighting	
Install controls to plan and inner systems	2-4
Convert incandescent to CFL	1-3
Replace exit signs with LED lamps	<2
Convert T12 to high efficiency T8s with electronic ballasts	2-5

Source: www.rockefellerfoundation.org

2.5 Resistance to Energy Efficiency Products

Energy Efficient Products although cheaper to operate are pricier than the conventional products that used are used in the market. In the government sector for example, the designer needs to adhere to Building Standard and Cost Guideline set-up by the Economic Planning Unit (EPU, 2005). This guideline basically limits expansive mechanical, electrical and architectural products only to category one buildings such as offices for ministers and top government officials. The constraints set may hamper the use of energy efficiency products that require bigger budget allocation in construction stage.

In financial sector, the growth of energy efficiency products also are not smooth as expected. According Jyoti (2008), lack of awareness and better understanding among the financial institutions in both India and China on potential of energy efficiency has made loan approval lower compared to other sector. A project was made to seek to remove the financial constraint by having specially trained officers to deals for energy efficiency and energy service company.

2.6 KKBB Energy Consumption

After checking the electricity bills for 12 months, it was found that the maximum peak demand of the building was in April 2013. It was found that the power consumption of the building was 68530kW for the whole month. At a Tenaga Nasional Berhad (TNB) rate of RM0.43 per kW-hour, the bill for the building was RM29,468 for that month. The other months also shows slightly lower value than April 2013.

Based on the Gross Floor Area of the building at 3,628 sq-meter, it works out that the peak design rate for this building is 45watt/m2, which is much larger than SIRIM's MS 1525 (Code Of Practice On Energy Efficiency And Use Of Renewable
Energy For Nonresidential Building), which stated that the peak design rate should be no more than 10Watt/M2 for it to be energy efficient building.

SIRIM, via its subsidiary SIRIM QAS International is a recognized organization of certification, inspection and testing services under a variety of body, including the National Accreditation Body, the Department of Standards Malaysia (STANDARDS MALAYSIA) and the United Kingdom Accreditation Service (UKAS) among others.

Figure 2.5 SIRIM certification is well accepted in Malaysia

2.7 Air Conditioning

Air conditioning is the technique of modifying, controlling and regulating climate conditions in a room, houses and offices for comfort reasons or for technical reasons like in laboratories, local manufacturing of electronic components, operating theaters, computer rooms, etc.

Air conditioning is a mode suitable thermal comfort when the outdoor temperature is high. In summer seasons, the need for air conditioning is due to external inputs (including solar), but also internal inputs (significant number of occupants, such meeting room, electrical appliances such as lighting, micro-computer.).

Air conditioning provides thermal comfort summer, between seasons, but also in winter using the same system for space heating. Comfort in humidity is also considered to provide controlled by the actions of humidification and dehumidification humidity. Air conditioning is essentially a heat pump to a size suitable for use.

An air conditioning system must not only address the thermal loads and water from a local source, but it must also ensure the quality of the air by the new hygienic air change (maintaining the CO_2 and odors to a level acceptable defined by the standards) , and of course the blown air filtration.

2.7.1 Split Air Conditioning

It is the most popular air condition type that used in most homes, schools and small office. It is sub-divided into several mounting positions explained in Table 2.4.

Table 2.4 Several types of split air-con in popular use

AC Parameters	Window AC	Wall Mounted AC	Cassette AC
Suitable For	Small rooms with a window sill	Any room with or without a window	Large indoor spaces
Noise	Relatively on the higher side	Minimal noise	Silent operation
Capacity range	0.75 ton to 2 ton	0.8 to 2 ton	1 ton to 4 ton
Advanced features	Humidity control, dust filter	Humidity control, dust filter, bacteria filter	Humidity control, dust filter, bacteria filter
Interference with home decor	Slight possibility to interfere with window curtains and drapes	Designer indoor units blend well with wall decor	Barely interferes with interior decor
Ease of installation	Minimal effort required	Indoor and outdoor units need some amount of effort for installation	Needs specialised false ceiling

Source: http://www.cromaretail.com/air-conditioner-capacity

2.7.2 Air – cooled Package

It is quite popular in Malaysia especially used in medium size office and lecture theatres at universities. It working principle is similar to split air-con except that its whole system located outside of the building and caters bigger cooling load (5 to 20 TR). Cool air is brought inside via ducted system. Figure 2.1 shows the air cooled package system cooling method.

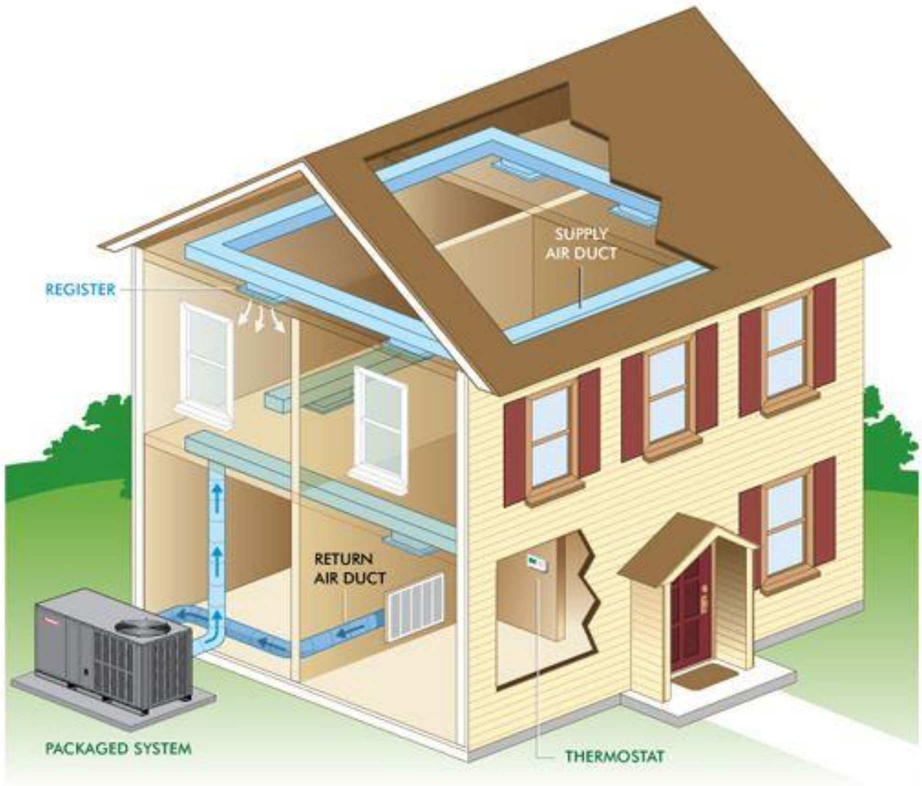


Figure 2.6 Air cooled package system cooling method.

Source: www.brighthubengineering.com/hvac

2.7.3 Water – cooled Package

It is most popular types of air conditioned use in large office buidings, shopping malls and electronics factories. The system however, consist several bulk components such as cooling towers, pumps and air handling units. Special space need to be sacrifice to cater these components. Water – cooled package is usually selected for a system that requires total refrigeration between 20 to 40 tons. Figure 2.3 shows the cross – section of typical cooling tower in use.

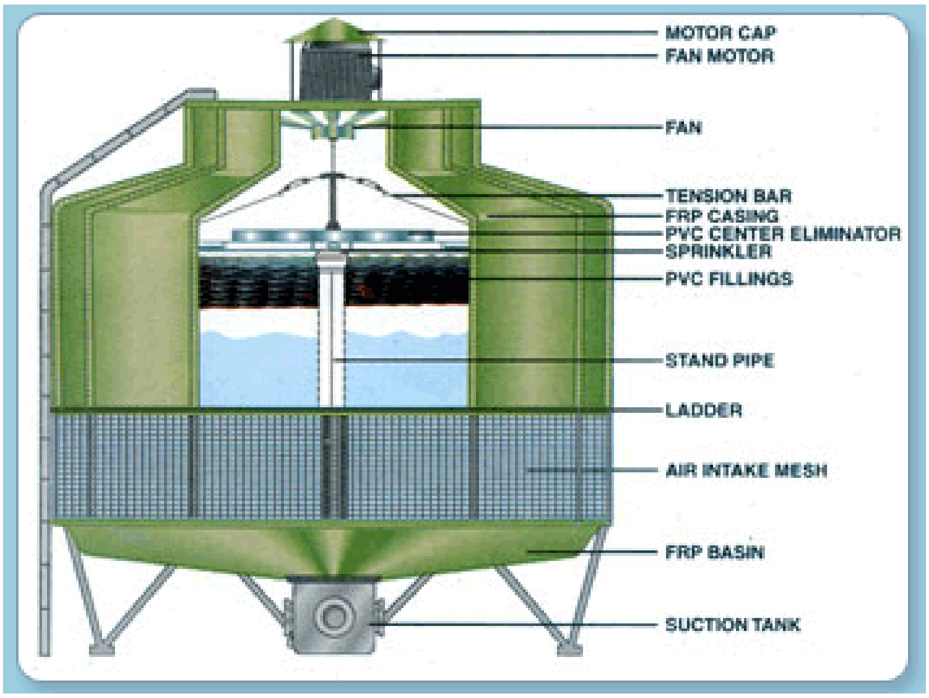


Figure 2.7 Cross section of cooling tower.

Source: www.alfacool.com

2.7.4 Refrigeration System Component

There are five basic components of a refrigeration system, these are:

a) Evaporator
b) Compressor
c) Condenser
d) Expansion Valve
e) The Refrigerant itself

2.7.4.1 Evaporator

The purpose of the evaporator is to take away unwanted heat from the product, through the liquid refrigerant. The refrigerant fluid contained in the evaporator is boiling at low pressure. This pressure level is determined by two factors. The first factor is the rate at which heat is absorbed from the product to liquid refrigerant in the evaporator and the second factor is the rate at which the low-pressure vapor is removed from the evaporator by the compressor.

To allow heat transfer, fluid coolant temperature must be lower than the temperature of refrigerated products. Once transferred, the coolant fluid taken from the evaporator by the compressor through the suction line. When the liquid refrigerant leaves the evaporator coil is in vapor form.

2.7.4.2 Compressor

The purpose of the compressor is to draw a low temperature, low pressure steam from the evaporator through the suction line. When pulled, the vapor compressed. When the vapor is compressed it increases in temperature. Therefore, compressor changes the steam from a low temperature steam to high temperature steam, thereby increasing the pressure. The vapor is then released from the compressor into the discharge line.

Figure 2.8 The compressor is located inside this outdoor unit
Source: www.energyauditsofchicagoland.com

2.7.4.3 Condenser

The purpose of the condenser is to remove heat from the refrigerant to the water outside. The condenser is usually placed on the roof of the building is reinforced, allowing the transfer of heat. Fans mounted on top of the condenser units are used to draw water through the condenser coils. High pressure steam temperature determines the temperature on the condensation begins.

As the heat has to flow from the condenser to the air, condensation temperature must be higher than that of water; usually between -12 ° C and -1 ° C. High pressure steam in the condenser is then cooled to a liquid refrigerant once again, while maintaining some of the heat. The refrigerant liquid then flows from the condenser to the liquid in the line.

Figure 2.9 The fins of the condenser that are designed to be slanted downwards

Source: www.dogruklima.com

2.7.4.4 Expansion Valve

In the cooling system, the expansion valve (Figure 2.11) is located at the end of the liquid line before the evaporator. High pressure liquid reaches the expansion valve, having come from the condenser. The valve then reduces air pressure as it passes through the orifice, which is located inside the valve. Reduce pressure, coolant temperature decreases to a level below the surrounding air. This low pressure, low temperature liquid is then pumped into the evaporator.

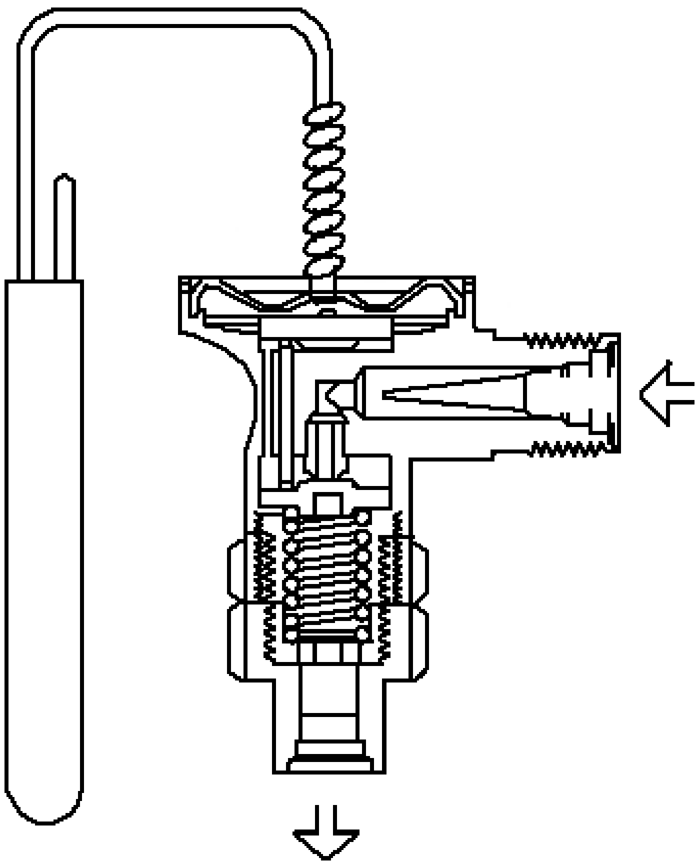


Figure 2.10 Cross-section of an expansion valve

Source: www.swtc.edu

2.7.4.8 Refrigeration Cycle

The refrigeration cycle begins with the refrigerant in the evaporator (Figure 2.12). At this stage of the refrigerant in the evaporator is in liquid form and is used to absorb heat from the product. When exiting the evaporator, the refrigerant has absorbed the heat quantity of the product and a low pressure, low temperature steam. This low pressure, low temperature vapor is then drawn from the evaporator by the compressor. When the vapor is compressed it increases in temperature.

Therefore, the steam changes from a steam of low temperature steam to high temperature steam, thereby increasing the pressure. This high temperature, high pressure steam is pumped from the compressor to the condenser, where it is cooled by the ambient, or in some cases with the help of a fan. Steam in the condenser cool only to the point where it becomes liquid again.

The heat, which has been absorbed, then run to the outside air. At this stage the liquid refrigerant run through the expansion valve. Expansion valve to reduce pressure liquid refrigerant and therefore reduce temperature. The cycle is completed when the refrigerant flow to the evaporator, the expansion valve, to be a low pressure, low temperature liquid.

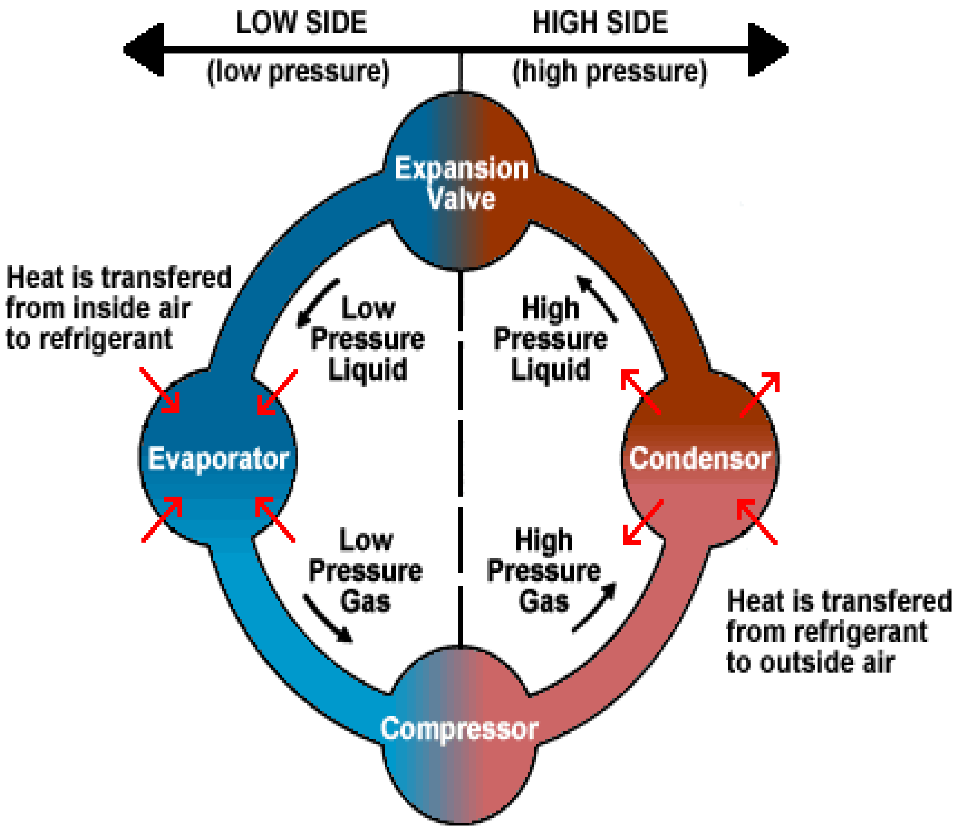


Figure 2.11 The refrigeration cycle

Source: www.swtc.edu

2.8 Lighting

Nowadays, because of the huge nature of the buildings, natural sunlight is not enough to enlighten inside the building. Lamps need to be use in order to replace the natural sunlight. Furthermore, most educational and office buildings nowadays are still operational till late at night.

There are several types of lamp that are commonly used in the market:

a) Incandescent light bulb, a heated filament inside a glass envelope
b) Fluorescent lamp, a light source that generates light by sending an electrical discharge through an ionized gas
c) LED lamp, a solid-state lamp that uses light-emitting diodes (LEDs) as the source of light
d) Other type such as laser, neon lamp , sulfur lamp and xenon arc lamp (Figure 2.12)

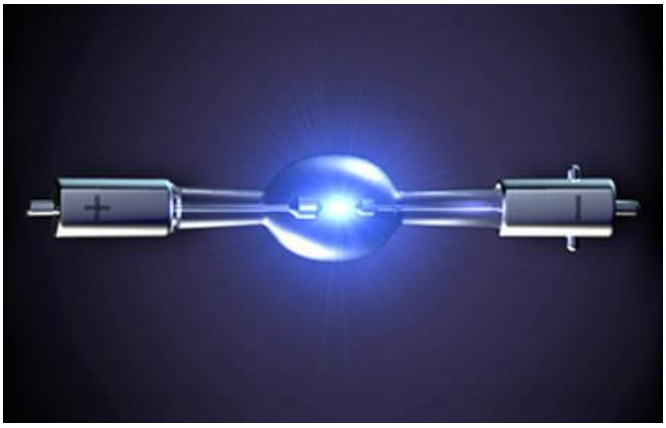


Figure 2.12 A xenon arc lamp

Source: www.furniturefashion.com

2.8.1 Incandescent Lamp

Incandescent lamps turns electricity into light by sending an electrical current through filament. The filaments usually made of tungsten metal. Resistance bulb filament heats up when electricity is supplied. Finally, the filament gets so hot that it glows, and producing light. This method was however not efficient in terms of energy usage. Many developed countries have started implementing a law to ban this type of lamp from being use.

Figure 2.13 A typical screw-type incandescent lamp

2.8.2 Fluorescent Lamp

Fluorescent lamps (Figure 2.14) are usually glass tubes filled with inert gas such as helium (He), neon (Ne), argon (Ar) and a small amount of mercury. When turned on, the electrons hit the argon gas and the mercury and excites it. The excited state doesn't last very long, and when the energy is released, it lets out a photon, that are particles of light. but the photons from mercury are not visible, they are ultraviolet. So by having a phosphor coating on the wall of the bulb, it lets out a photon that we can see, and light is made. Changing the type of phosphor can change the color we see, depending on the user requirements.

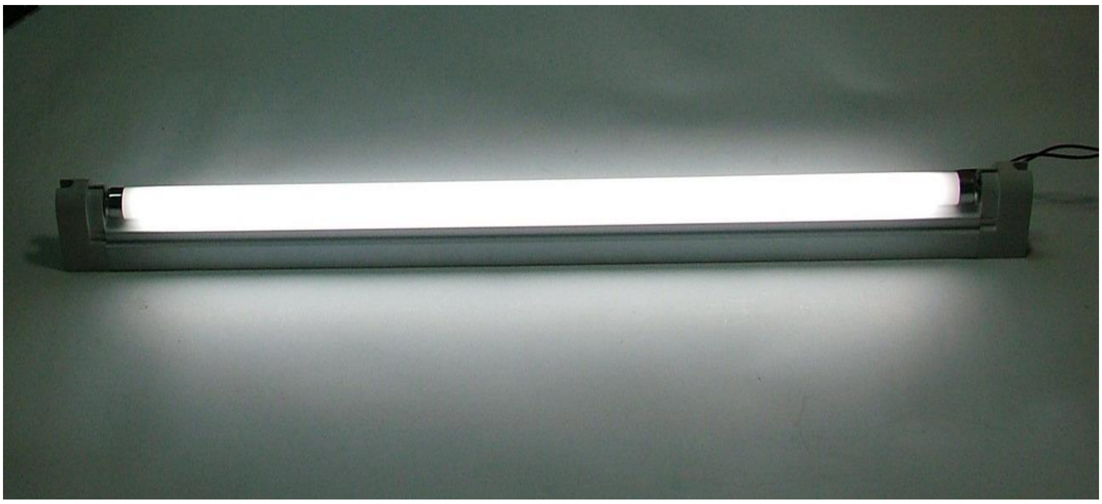


Figure 2.14 A typical fluoroscent lamp

2.8.3 L.E.D Lamp

Since L.E.D lamps are chosen to be used in this study. It will be discussed further in the later chapter.

2.8.4 Photometry Units

In order to choose a suitable lamps, several data needs to be knows beforehand. Among them are as listed in Table 2.5.

Table 2.5: SI Photometry Units

Quantity		**Unit**		**Dimension**
Name	Symbol	**Name**	**Symbol**	**Symbol**
Luminous energy	Qv	lumen second	lm·s	T·J
Luminous flux	Φ_v	lumen (= cd·sr)	lm	J
Luminous intensity	I_v	candela (= lm/sr)	cd	J
Luminance	L_v	candela per square metre	cd/m^2	$\mathbf{L}^{-2}\cdot\mathbf{J}$
Illuminance	E_v	lux (= lm/m2)	lx	$\mathbf{L}^{-2}\cdot\mathbf{J}$
Luminous emittance	M_v	lux (= lm/m^2)	lx	$\mathbf{L}^{-2}\cdot\mathbf{J}$
Luminous efficacy	η	lumen per watt	lm/W	$\mathbf{M}^{-1}\cdot\mathbf{L}^{-2}\cdot\mathbf{T}^{3}\cdot\mathbf{J}$
Luminous efficiency	V			1

2.9 Conclusion

It can be concluded from this chapter that Green Building is a trend forward that must be embrace by every project or building owner regardless of the higher initial cost. In any building, air conditioning and lighting are the most common contributor of higher energy usage, thus higher electricity bills. KKBB building meanwhile, although too far from being Green or Energy Efficient building, will be studied further in order to reduce its energy usage by using innovative products.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

In order to achieve the aim and objectives, a systematic methodology should be deployed. Generally, it consists of four phase which are planning phase, data collection phase, analysis phase and reporting phase. A case study is conducted on KKBB building where energy consumption will be tracked and observed from previous billings. On the other hand, energy cost saving analysis will be determined by using as built drawing, inventory list, interview, and calculation.

3.2 Literature Review

In order to understand to the basics of the work that are desired to be carried out, extensive readings from previous studies and researches that are related to retrofitting office building are essential. It is carried out to establish knowledge of the research study. The sourced material consists of internet, journals, articles, reference books and previous research.

3.3 Case Study

A case study is conducted on KKBB building which is selected based on their purpose as Community College serving the local students. The inventory of appliances in that building is listed for the calculation of energy consumption. All available appliances are analyzed via energy consumption analysis based on frequency and period uses.

For cost saving measurement, the suggestion is made for new innovative solutions which comply to the green building requirements. A significant amount of saving is expected to be made at the end of the project.

Figure 3.1 A view in the college's library where lighting and air conditioning were in constant use.

3.4 Development of Questionaire

In order to develop the questionnaire, supervisor is consulted to get a better idea of type of questions to ask. The content is basically sourced from literature review particularly on Green Building and KKBB current energy usage.

3.5 Data Collection

The data collected basically falls into two categories, which are Primary Data and Secondary Data. The details are as per explanation below.

3.5.1 Primary Data

Primary data is obtained via interview. The interview involves staffs that directly assigned to maintain the building who have insight knowledge of the building condition itself. The maintenance team comprised of Maintenance Officer, its deputy and another two Mechanical and Electrical technicians. Other non-technical staffs were also consulted in order to get more holistic view of the building from layman perspectives.

3.5.2 Secondary Data

Secondary data is collected from electricity bills at KKBB. Detail data for every month will be used as comparison. The power consumption of each equipment is also collected.

3.6 Data Analysis

Data collected from primary and secondary data above mentioned is organized, analysed and summarized so that suggestion of innovative solutions can be proposed. Microsoft Excel is used because it is simple to use and easily available.

3.7 Result And Interpretation

The data were analysed where the result is expected to meet objectives. Microsoft Office Excel are used to analyse the data. The raw results are then interpreted so that it is understandable by layman.

3.8 Proposal

A proposal is made by the end of the study in order for the building to be Energy Efficient building.

Figure 3.2 The picture of two cooling towers at the back of the building. A proposal will be made to remove them at the end of this report.

3.9 Summary

A systematic methodology is vital and should be deployed. All the results including interviews should be systematically arranged so that it can be easily retrieved whenever wanted. The data also need to be carefully analyzed in order to propose better solutions towards the end of this study.

CHAPTER 4

FINDINGS AND ANALYSIS

4.1 Introduction

After going through the building equipments and facilities, it is found out there are two major services that can be improved to lower the energy used in the building, namely air-conditioning and lighting. Although other items in the buildings such as water heater and oven also could be improved, these two factors mentioned below were found out to be the biggest contributor of high energy usage.

4.2 Air-Conditioning

It was found that the building was cooled by using water cooled package system. Two cooling towers are located at the back of the building supplying cold water to Air Handling Units (AHU) at every floor. The total cooling load for the AHU at the building was found out to be 1,200,000btu/h that requires 351kW/hour to run the air-conditoning water cooled package system.

Figure 4.1 Picture of Current Air Handling Unit at level 2. Using VRF the AHUs will no longer be used.

For 21 days of operation for 8 hours per day, it is found that the building air-conditioning power consumption was 58,968kW, which is equivalent to RM25,356.24 (note: total bill RM29,468). This is notably high considering that the college has different timetable for students, where most of the time not even half of the rooms were used. To cool the empty rooms is a waste of electricity and money to pay the bills. Therefore, Variable Refrigerant Flow (VRF) is proposed to be installed for cooling purposes.

VRF system is a newly established method of providing precise cooling control to indoor environments via pumping the refrigerant directly to indoor units. VRF offers a wide variety of applications from spot-cooling rooms in bungalow to a large building with multiple floors and areas like the one used in Mahkamah Jalan Duta building.

VRF compressor pumped refrigerant to the zone to be cooled, allowing the temperature of that area to be more precisely controlled. It can concurrently cool some zones while heating (in temperate countries that requires heater) other areas or just provide comfort control to zones that are in use.

Figure 4.2 A typical layout of VRF system
Source: www.johnsoncontrols.com

At a rate of RM350 per square metre, the cost to install VRF systems is RM1,080,000.   Meanwhile, the amount of electricity bills expected to be saved per month is RM12,678, which is half the current air – conditioning amount.

Therefore, the payback period to recoup back the investment of installing VRF system will be 85.2 months or 7 years and 2 months, via following formula:

RM1,080,000 (cost installing VRF) / RM12,678 (bill save per month) = 85.2 months

4.3 Lighting

Currently, the college is using the conventional T8 36W lamp. The lamp, although is cheap consume higher energy and thus contributes to higher electricity bills. A LED lamp is a series of light-emitting diode that is positioned straight in-line to follow current light bulb for use in lighting fixtures.

Figure 4.3 LED lamp T8-18W that is currently available in the market.
Source: etprojektai.lt/LED_T8.html

Table 4.1 shows that the LED light consumed 62W less power than the standard T8 36W currently used

Table 4.1 Comparison of Std T8 36W vs LED T8 – 18W

Item	**Lamp Type**	**Ballast**	**Color Temp (^{0}K)**	**Total Power (W)**	**Life Time (Hours)**
1	Std. T8 36W	Magnetic	6500	80	20,000
2	LED T8 - 18W	Driver	6500	18	35,000
			Power Saving	**62**	

In total, there are 549 units of Standard T8 26W x 2 throughout the building as per Table 4.2 below.

Table 4.2 Number of 36Wx2 Lamps in the building

	No Of Lamps (36W x2)	Area (sq.m)
Ground Floor	110	794
1st Floor	124	877
2nd Floor	171	1023
3rd Floor	144	934
Total	549	3628

Therefore, overall energy saving by using LED lamps is 34,038W (34kW), via following formula:

62W(energy saving per lamp) x 549 (no. of lamps)= 34,038W

Overall power reduction per month will then be 2,856kW, via following formula:

[34kW(per-day) x 21days x 8 hours]/ 2* = 2,856Kw

*2 - divided by two assuming half of the building occupied at a time due to different students timetable

Total electricity save will be RM 1,228 per month, via following formula:

2,856kW x RM0.43 (current TNB industrial rate) = RM 1,228 per month

Table 4.3 Cost of standard T8 lamp vs LED lamps

Item	**Type**	**Lighting Component**	**Dimension**
			1200 mm
1	T8 Magnetic (36W)	Bulb (tube) Magnetic Ballast	RM9.50 RM12.50
			RM22.00
2	LED (18W)	Bulb (tube) c/w driver	RM95.00
			RM95.00

Based on Table 4.3 above, the cost to replace the current lamp with 549 units of LED lamps is RM52,155, via following formula:

549 units x RM95= RM52,155

Therefore, the payback period will be 42.5 months or 3 years and 6 months to recoup the investment of changing to LED lamps, via following formula:

RM52,155 (LED replacement cost)/ RM1,228 (bill save per month) = 42.5 months

4.4 Summary

The summary of initial cost and the payback period for both method discussed previously are as the following:

Table 4.4 Summary of initial cost and the payback period

Solution Proposed	**Initial Cost**	**Electricity Bill Saved per month**	**Payback period**
Changing to VRF air-con	RM1,080,000	RM12,678	7 years and 2 months
Changing to LED lamp	RM52,155	RM1,228	3 years and 6 months
Implement both	RM1,132,155	RM13,906	10 years and 8 months

It can be seen that should the college decide to implement both options, they need to spend more than RM1 million. The VRF system has longer payback period but will lessen the burden of paying electricity bills tremendously. The LED lamp however, has lower initial cost and should be prioritised if the college has short of fund.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Introduction

This chapter will relate back the aim and objective of the project. Each objective will be counter-check to see whether the objective has been achieved. Then the aim of the project should be identified whether has been achieved or not.

5.2 Summary of Finding

5.2.1 <u>Objective 1: To identify the energy consumption of KKBB</u>

From the data obtained the building consumed maximum energy of 68530kW. This translates to electricity bill of RM29,468.

5.2.2 <u>Objective 2: To investigate the requirement of energy efficient building in Malaysia</u>

Based on SIRIM’s MS 1525 (Code Of Practice On Energy Efficiency And Use Of Renewable Energy For Nonresidential Building) the peak design rate of any Nonresidential building should be no more than 10Watt/M2.

5.2.3 Objective 3 :To examine the expected cost saving of KKBB after using the propose innovative solution(s)

If both innovative solutions are implemented, KKBB will had a reduction of electricity bills amounting RM13,906 from the initial investment of RM1,132,155. Based on payback analysis this amount of money could be recoup within ten years and eight months. Since the cooling towers and the Air Handling Units will no longer be used, it should be sell as second hand products to anyone interested and thus will contribute extra money to KKBB.

5.3 Conclusion

The study has identified two solutions by using innovative products that are readily available in the market. Both solutions will reduce energy consumption and thus electricity bills for KKBB. The changing of water-cooled package air- conditioning system into VRF system will have a payback period of 7 years and 2 months whereas the changing of current fluorescent lamp into LED lamp will have a payback period of 3 years and 6 months. Thus the aim of this project of proposing innovative products towards better energy efficient KKBB is accomplished.

5.4 Recommendations for Future Study

For future study, it is hoped that the other four remaining GBI criteria stated earlier will be analysed and proposed. Perhaps with the combination of all six GBI criteria KKBB will be fully certified as Green Building.

A study on other community colleges also could be done in ensuring that energy is not wasted unnecessarily.

6.0 REFERENCES

Yan Ji and Stellios Plainiotis (2006): Design for Sustainability. Beijing: China Architecture and Building Press.

U.S. Environmental Protection Agency. (2009). Green Building Basic Information. www.epa.gov/greenbuilding/

Cassidy, R. (2003). *White Paper on Sustainability.*2011

SIRIM's MS 1525 (Code Of Practice On Energy Efficiency And Use Of Renewable
Energy For Nonresidential Building),

Kementerian Tenaga, Teknologi Hijau dan Air (KeTTHA) (2013). *Green Energy Criteria*

Kibert, C. (2005). *Sustainable Construction: Green Building Design and Delivery.*

Leanne Tobias (2009). *Retrofitting Office Buildings to be Green and Energy Efficient.*

Francis W. H. Yik (2002). *Building Energy Efficiency And Remuneration Of Maintenance And Operation Personnel.*

Jyoti Prasad Painuly (2008) *Financing energy efficiency: lessons from experiences in India and China*

Suvarna Ooi (2010). *Embracing Green Energy.*

U.S. Environmental Protection Agency. Green Building Home. http://www.epa.gov/greenbuilding/

www.greenbuildingindex.org

www.brighthubengineering.com/hvac

http://www.cromaretail.com/air-conditioner-capacity

www.energyauditsofchicagoland.com

www.ucsusa.org

www.alfacool.com

U.S Building Energy Retrofits (2012) www.rockefellerfoundation.org

Building Standard And Cost Guidelines (2005) www.epu.gov.my

www.dbcca.com/research